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Online Slurry Air-content Determination and Analysis (OSADA) Technology for Oil Sand Development at Syncrude

©

by

Houshang Ghazi

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

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ABSTRACT

At Syncrude, slurry pipeline hydrotransportation is a means for reducing oil sands ore haulage cost by dump trucks. A greater understanding and knowledge is required in this area to optimize an efficient hydro-transport system.

The challenge in this project (thesis) was to detect the amount of air holdup within a flow of water, air mixture and solid (two and three phases) in a test loop, in the Syncrude slurry pipeline, and in an experimental bubbling water column, by means of the sound waves.

A relationship was established between the air content of the flow and its resonance frequency caused by the proper external audible sound wave (active means). Also, the generated audible noise spectrum of the slurry pipeline during the operation was measured and recorded (passive means). Its existing natural resonance frequencies were identified and then were related to its amount of air content.

Key words: Air Content, Bubble Holdup, Dispersed Phases, Audible & Ultrasound, Resonance

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Above all the author wishes to dedicate this work to his loving wife Minoo, and son Hooman. The author recognizes and appreciates their encouragement, patient, help and cooperation during his years of study for his M. Eng. degree at mechanical engineering and for M.Sc. degree at mining engineering of University of Alberta.

Houshang Ghazi
January 6, 2003

TABLE OF CONTENT

CHAPTER 1:

GENERAL INTRODUCTION 1

1.1 Pump Performance with Gas in Slurries 3

1.2 Gas content measurement in slurries 5

CHAPTER 2:

LITERATURE SURVEY 8

2.1 GENERAL CHARACTERISTICS OF FLUID MOTION IN ROUND PIPES 8

2.2 CURRENT FORMULATION of CONSERVATION and BALANCE EQUATIONS for MULTIPHASE FLOW MODELING 11

CHAPTER 3:

GENERAL APPROACHES FOR THE THESIS 12

CHAPTER 4:

RESONANT FREQUENCY TESTS 13

4.1 INTRODUCTION 13

4.2 THEORETICAL DEVELOPMENT 14

4.2.1 LITERATURE SURVEY 15

4.2.1.1 Acoustical Waves in a Homogeneous Mixture 15

4.3 METHODOLOGY AND RESEARCH OBJECTIVES 17

4.4 APROACH FOR THE RESONANT FREQUENCY TEST 17

4.5 TEST PROCEDURE 18

4.5.1 TEST SETUP 18

4.5.2 WHAT WAS TO BE MEASURED? 23

4.5.3 REFILLING AND DRAINING THE PIPE LOOP SYSTEM 23

4.5.4 HOW THE MEASUREMENT TOOK PLACE? 24

4.6 EXPERIMENTATION 30

4.6.1 PIPING LOOP SET UP AND INITIAL EXPERIMENTATION 30

4.6.2 EXPERIMENTATION WITH THE FULL LOOP 31

4.7 TEST RESULTS AND INTERPRETATION 31

4.7.1 FOR TWO PHASE FLUID (WATER AND AIR) 31

4.7.2 FOR THREE-PHASE FLUID (WATER, AIR, AND SOLID) 43

4.8 CONCLUSION TO THE FIRST APPROACH 49

CHAPTER 5:

NOISE SPECTRUM TESTS 50

5.1 INTRODUCTION 50

5.2 THEORETICAL DEVELOPMENT 51

5.2.1 SOUND LEVEL MEASUREMENT 51

5.2.2 SOUND POWER LEVEL MEASUREMENT 57
5.2.3 BARRIER MATERIALS ON THE SOUND PATH 58
5.2.4 RESONANCE ACROSS A PIPE 60
5.3 METHODOLOGY AND RESEARCH OBJECTIVES 61
5.4 APPROACH 62
5.5 NOISE LEVEL MEASUREMENT OF THE SLURRY PIPELINES AT SYNCRUDE MINE SITES 63
5.5.1 PIPE MEASUREMENT POSITIONS 63
5.5.2 MEASUREMENT AT NORTH MINE 64
5.5.3 MEASUREMENT AT AURORA MINE 72
5.6 PIPELINE MEASUREMENT METHODOLOGY AND APPROACH 81
5.7 MEASUREMENT CONDITION 81
5.8 SEARCHING THE MEASUREMENT RESULTS FOR RESONANCE 82
5.8.1 THEORETICAL RESONANCE AND SPEED OF SOUND ACROSS THE 27” PIPELINE 82
5.9 CONCLUSION TO THE SECOND APPROACH 93

CHAPTER 6:

OVERALL CONCLUSION TO THE THESIS 94
Specification of the Instruments Used 95
REFERENCES 96

CHAPTER 7:

APPENDIX 100

7.1 Steel Pipe Data 100

7.2 Resonance test result tables for the two-phase (water, air) fluid flow 104

7.3 Resonance test result tables for the three- phase (water, air, solid) fluid flow 110

7.4 Sound Level Measurement at North Mine 112

- 7.4.1 Ambient 112
- 7.4.2 Pipeline side 117
- 7.4.3 Pipeline top 131

7.5 Sound Level Measurement at Aurora Mine 145

- 7.5.1 Ambient 145
- 7.5.2 Pipeline Bottom 150
- 7.5.3 Pipeline Side 164
- 7.5.4 Pipeline Top 178

7.6 PICTURES 192

LIST OF TABLES

Table 4-1: Kinematic Viscosities (ν) of Water and Air 20
Table 4-2: Physical properties for some common materials 26
Table 4-3: Speed of Sound in 1.5” PVC pipe 28
Table 5-1: Average ambient sound level spectrum, North Mine 66
Table 5-2: Average net inside pipeline sound level spectrum (side) of slurry flow, North Mine 68
Table 5-3: Average net inside pipeline sound level spectrum (top) of slurry flow, North Mine 70
Table 5-4: Average ambient sound level spectrum, Aurora Mine 73
Table 5-5: Average net inside pipeline sound level spectrum (bottom) of slurry flow, Aurora Mine 75
Table 5-6: Average net inside pipeline sound level spectrum (side) of slurry flow, Aurora Mine 77
Table 5-7: Average net inside pipeline sound level spectrum (top) of slurry flow, Aurora Mine 79
Table 5-8: Resonance searching of 27” pipeline (side), North Mine 88
Table 5-9: Air content searching of 27” pipeline (side), North Mine 90
Table 5-10: Resonance grouping of 27” pipeline (side), North Mine 91
Table 7-1: Commercial rough steel pipe data (Crane 1986) 100
Table 7-2: Properties of large diameter water supply piping (King 1967) 104

LIST OF FIGURES

Figure 1-1:	The Aurora mine will use the next generation of surface mining and extraction technology	2
Figure 1-2:	Pump Performance	4
Figure 1-3:	Pump Performance	4
Figure 1-4:	EAPS	7
Figure 1-5:	Damper-mass model for inertia of fluid	9
Figure 4-1:	Schematic of First Harmonic across the Pipe	13
Figure 4-2:	Laminar, turbulent flow and Raynolds number	21
Figure 4-3:	Experimental Tests Loop	22
Figure 4-4:	Instrumentation hook up for the loop	25
Figure 4-5:	Theoretical Resonance Frequencies of a 11 cm (4.33") Diameter PVC Pipe	29
Figure 4-6:	Resonance Frequencies of a 1.5" Pipe (Water & Air) At 3190 RPM	34
Figure 4-7:	Resonance Frequencies of a 1.5" Pipe (Water & Air) At 2900 RPM	34
Figure 4-8:	Resonance Frequencies of a 1.5" Pipe (Water & Air) At 2610 RPM	35
Figure 4-9:	Resonance Frequencies of a 1.5" Pipe (Water & Air) At 2320 RPM	35
Figure 4-10:	Resonance Frequencies of a 1.5" Pipe (Water & Air) At 2030 RPM	36
Figure 4-11:	Resonance Frequencies of a 1.5" Pipe (Water & Air) At 1740 RPM	36
Figure 4-12:	Resonance Frequencies of a 1.5" Pipe (Water & Air) At 1450 RPM	37
Figure 4-13:	Resonance Frequencies of a 1.5" Pipe (Water & Air)	

At 1160 RPM 37
Figure 4-14: Resonance Frequencies of a 1.5” Pipe (Water & Air) At 870 RPM 38
Figure 4-15: Resonance Frequencies of a 1.5” Pipe (Water & Air) At 580 RPM 38
Figure 4-16: Resonance Frequencies of a 1.5” Pipe (Water & Air) At 290 RPM 39
Figure 4-17: Resonance Frequencies of a 1.5” PVC Pipe (Water & Air) at All RPMs 40
Figure 4-18: Tested Resonance Frequencies of a 1.5” PVC Pipe (Water & Air) 42
Figure 4-19: Average Resonance Frequencies of a 1.5" PVC Pipe (Water, Air, 5%Solid) at Different Frequencies 45
Figure 4-20: Theoretical Resonance Frequencies of a 1.5" PVC Pipe (Water, Air, 5% Solid) 46
Figure 4-21: Tested Resonance Frequencies of a 1.5" PVC Pipe (Water, Air, Beads) 48
Figure 5-1: Relative Response Functions for A, B, and C weightings 53
Figure 5-2: Decibel Addition Function $C_+(\Delta L)$ 53
Figure 5-3: First resonance mode across a pipe’s diameter 60
Figure 5-4: Measurement points on the pipeline 63
Figure 5-5: Average ambient sound level spectrum, North Mine 67
Figure 5-6: Average net inside pipeline sound level spectrum (side) of slurry flow at North Mine 27” line 69
Figure 5-7: Average net inside pipeline sound level spectrum (top) of slurry flow at North Mine 27” line 71
Figure 5-8: Average ambient sound level spectrum, Aurora 74
Figure 5-9: Average net inside pipeline sound level spectrum (bottom) of slurry flow at Aurora 30” line 76
Figure 5-10: Average net inside pipeline sound level spectrum (side) of slurry flow at Aurora 30” line 78

Figure 5-11:	Average net inside pipeline sound level spectrum (top) of slurry flow at Aurora 30” line	80
Figure 5-12:	Theoretical Resonance Frequency and Speed of Sound Across 27” Slurry Pipeline at North Mine	84
Figure 5-13:	Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27” Line, Test # 1	86
Figure 5-14:	Speed of Sound and Resonance at Side of 27” Pipeline North Mine	92

NOMENCLATURE

Symbols Used	**(Equation #)**	**Definition**
A :	(E4-10)	Pipe cross section area (m^2)
B:	(E4-2)	Bulk modulus of material (Pa)
B :	(E5-5)	Plate bending stiffness per unit width (N/m)
C :	(E4-1)	Speed of sound in the slurry (m/s)
c :	(E4-7)	Sound velocity (m/s)
D:	(E4-1)	Diameter of the pipe (m)
E_p:	(E4-2)	Elasticity modulus of pipe (Pa)
f:	(E4-15)	Resistance coefficient of pipe surface (unit less)
f:	(E5-8)	Frequency (Hz)
f_1:	(E4-1)	First harmonics frequency (Hz)
H :	(E4-12)	Pump head (m)
I_i :	(E5-5)	Sound intensity incident (W/m^2)
I_t :	(E5-5)	Sound intensity transmitted (W/m^2)
L :	(E4-15)	Pipe length (m)
L :	(E5-2)	Sound level (dB)
I :	(E5-6)	Sound intensity (W/m^2)
P:	(E2-1)	Pressure (Pa)
P_i :	(E5-5)	Sound pressure incident (P_a)
P_{ref}:	(E5-1)	Reference sound pressure (amplitude in Pa)
P'_{rms} :	(E5-1)	Sound pressure (amplitude in Pa)
P_t:	(E5-5)	Sound pressure transmitted (P_a)
Q :	(E4-10)	Flow rate (m^3/s)
R :	(E2-1)	Resistivity (Kg/m^3s)

Re :	(E4-11)	Reynolds number
t:	(E4-2)	Wall thickness of pipe (m)
$\overline{U}$:	(E2-1)	Complex mean velocity, averaged across the pipe at t = 0°, and t = 90° in the cycle (m/s)
$\overline{U'}$:	(E2-1)	Time derivative of $\overline{U}$ along the pipe (m/s^2)
V :	(E4-10)	Flow velocity (m/s)
W :	(E5-3)	Sound power output (m/s)
W :	(E5-8)	Surface density (kg/m^2/cm, thickness or lb/ft^2/in, thickness)
W_i :	(E5-4)	Sound power incident (watt)
W_{rep} :	(E5-3)	Sound power reference (watt)
W_t :	(E5-4)	Sound power transmitted (watt)
X:	(E2-1)	Distance along the pipe (m)
Z :	(E4-12)	Elevation (m)
α:	(E4-2)	Volumetric proportion
η :	(E5-5)	Composite plate loss factor (unit less)
λ_1:	(E4-1)	First harmonics wave length (m)
ν :	(E4-11)	Kinematic viscosity (m^2/s)
θ :	(E5-5)	Angle of incident (radian)
ρ :	(E5-5)	Density of medium (kg/m^3)
ρ_e :	(E2-1)	Effective density (kg/m^3)
ρ_m:	(E4-2)	Mixture density (kg/m^3)
ρ_s :	(E5-5)	Plate surface density (kg/m^2)
τ :	(E5-4)	Sound transmission coefficient

CHAPTER 1:

GENERAL INTRODUCTION

At Syncrude mine sites, located about 30 km north of the town of Fort McMurray most of the ore is now transported by hydrotransportation pipelines. Currently there are four major hydrotransport pipelines at Syncrude sites. One pipeline is located at EAPS (Extraction Auxiliary Production System), two pipelines at North Mine, and one at Aurora Mine. The typical operating rates for the systems are about 4000 to 8000 t/hour of oil sand and with the slurry flow rate of 0.7 to 1.2 m^3/s. The diameters of the pipelines range from 0.6 to 0.8 m, and their lengths from 2.5 to 4.3 km. Transported oil sand slurry goes into the processing plant. There bitumen is floated off the slurry, and then processed into a marketable synthetic crude oil. Currently daily Syncrude crude oil production is about 250,000 Bbls/day (39,750 m^3/day). That amounts to about for 12% of Canada's current crude oil consumption.

The Aurora Mine will use the next generation of Surface Mining and Extraction Technology

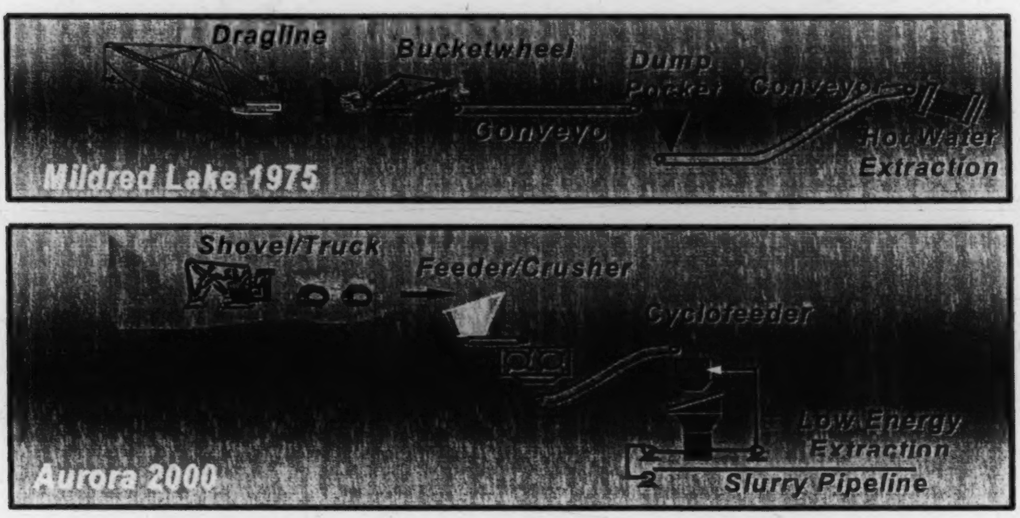

Dragline
Bucketwheel
Dump Pocket
Conveyor
Conveyo
Hot Water Extraction
Mildred Lake 1975
Shovel/Truck
Feeder/Crusher
Cyclofeeder
Low Energy Extraction
Slurry Pipeline
Aurora 2000

Figure 1-1

1.1: PUMP PERFORMANCE WITH GAS IN SLURRIES

Air and gas can get into the slurry pipelines in a number of different ways. The tar sand feed may contain some air in the pores of lumps at the time it is mixed with hot water. Air and gas may be lost or gained in the pump box, especially if the flow is very turbulent. Finally some air and gas may be liberated from the bitumen as the oil sand mixes with the hot water.

The detrimental effect of gas existence in the fluid on pump performance has been known for sometime. Not much data about the effect is available in the literature. The effect of air or gas content in a fluid on pump performance is fairly complicated. It is generally known that the effect depends on the volumetric proportion of the gas in the slurry, type and size of pump used, the type of gas, the type of fluid, the pump flow rate, the fluid temperature, and the pressure at the pump inlet and outlet. Thus as the pressure of the flow increases, the effect would be lower. In general, the pump performance is degraded when there is gas in the fluid, particularly at higher flow rates and low pump inlet pressure.

(Stepanoff, 1957) has indicated that for a 10-inch (25 cm) volute pump at relatively high flows and at ambient suction pressure, a 2% by volume air in water can give an efficiency ratio degrade to about 85% (Fig. 1-2). Under the same condition and if the air volume was increased to 4%, then the efficiency ratio may be degraded further and that was down to 70%. (Florjancic, reference in Herbich) has measured both efficiency and head ratios to be at 85% and 0.85, with air addition of 4% by volume (measured at the inlet pressure of 250 kPa). For the 5% air volume at the same inlet pressure, the efficiency ratio was down to 79% and the head ratio was degraded to 0.75 only (Fig. 1-3). Better pump performance was measured at higher inlet pressures, even with the same volumetric air contents at the pump inlet.

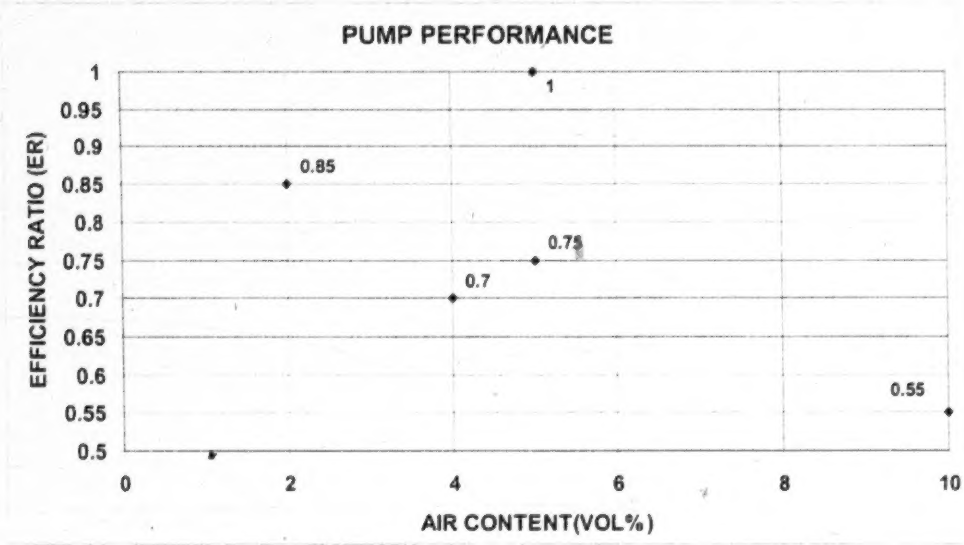


Figure 1-2

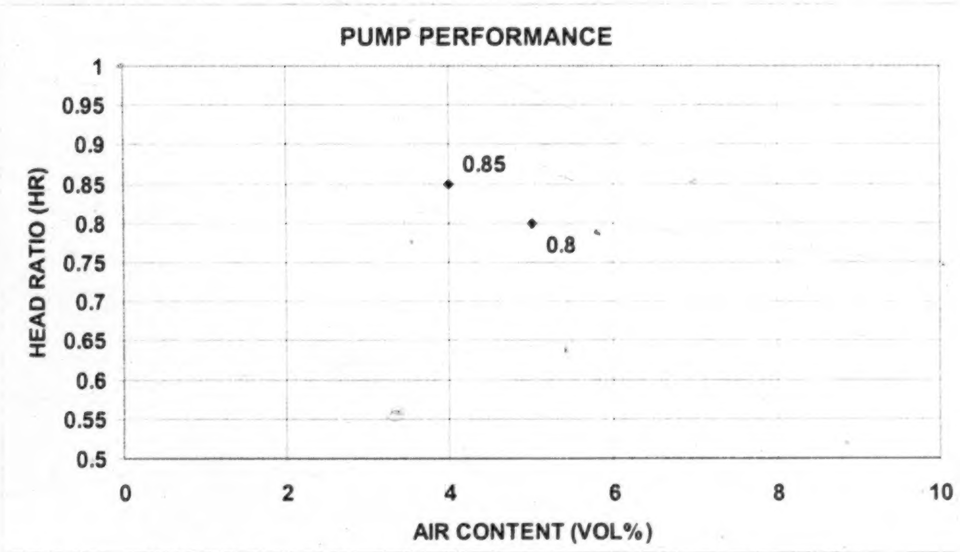


Figure 1-3

Normally in the oil sand slurry pipelines, the amount of gas (air) in the slurry is expected to be relatively small with only a few volume percentages. But even this small gas amount may affect the overall pump efficiency to some degree, and result in increased power draws in the pipeline system. In the oil sand slurries, on the other hand, some gas (air) is required to improve the bitumen recovery at the processing plant. There is therefore a trade-off between the needed amount of air for bitumen recovery and the degrading of the pump efficiency.

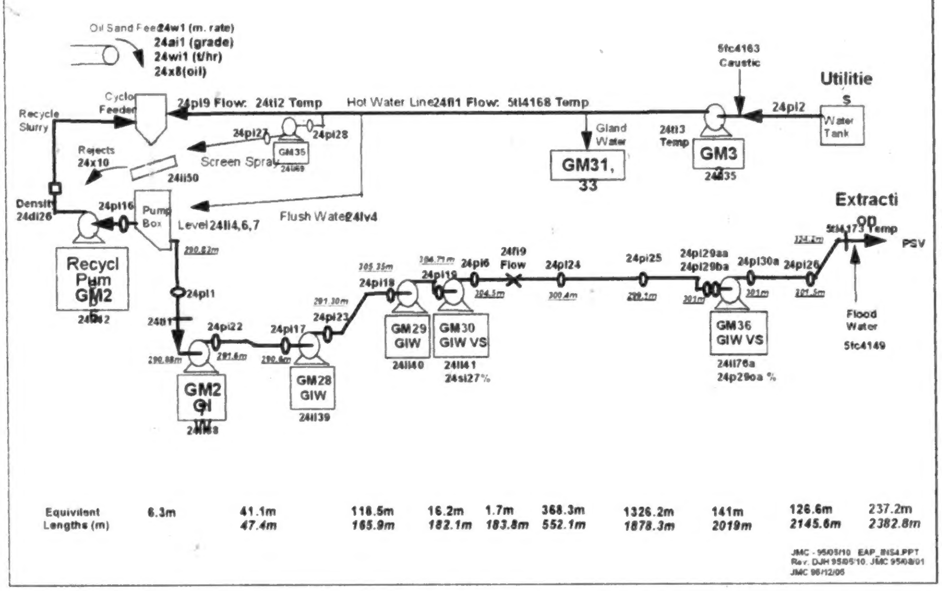
1.2: GAS CONTENT MEASUREMENT IN SLURRIES

The existing methods for measurement of gas content in slurries include the following:

1. Finding out what gas content of slurry is by sampling and analyzing it. The sampling is not an easy task and care should be taken to preserve the gas content of the taken sample. The solid and bitumen in the slurry would complicate the measurement. The method is not online or continuous.
2. Measuring gas content by means of nuclear density gauges. The gauges basically measure the average fluid density. In the case of existing gas content, the density reading would be lower than gas-free fluid. The method for measuring slurries is very difficult because the density of the flow varies continuously, and the gas-free fluid density could not be easily determined.
3. Estimating gas content of slurry based on the compressibility of the slurry. A working slurry pipeline could be shut down; the ends sealed off by shut-off valves, and the pipeline pressurized by water. The rise in pressure can then be determined from the derived fluid compressibility. In the past, Syncrude has used this method on some experimental pipeline loops. But it is not easy to carry out the experiment on a commercial pipeline.

4. Determining gas content in the slurries through the use of pump efficiency data. The pump efficiencies are affected by gas content. The solid content of slurry may also degrade efficiency and may mask the effect of gas (Coward, 1997).
5. In a pipeline, the gas content may be estimated by measuring the speed of sound as it was the intention of this thesis.

Figure 1-4: EAPS INSRUMENTATION



Oil Sand Feed 24w1 (m. rate)
24ai1 (grade)
24wi1 (t/hr)
24x8(oil)
Cyclo Feeder
Recycle Slurry
24pl9 Flow: 24tl2 Temp
Hot Water Line 24fl1 Flow: 5tl4168 Temp
24pl27
24pl28
GM35
24ll69
Rejects 24x10
Screen Spray
24ll50
Density 24dl26
24pl16
Pump Box
Level 24ll4,6,7
Flush Water 24lv4
Recycl Pump GM25
24ll42
290.82m
24pl1
24fl1
24pi22
24pl17
24pl23
24pl18
24pl19
24pl6
291.30m
305.35m
304.5m
GM2 GIW
24ll68
290.88m
GM28 GIW
24ll39
GM29 GIW
24ll40
GM30 GIW VS
24ll41
24si27%
Gland Water
GM31, 33
5fc4163 Caustic
Utilities
24pl2
Water Tank
24tl3 Temp
GM32
24ll35
24fl9 Flow
24pl24
300.4m
24pi25
24pl29aa
24pl29ba
24pl30a
24pl26
301m
GM36 GIW VS
24ll76a
24p29oa %
Extraction
5tl4173 Temp
PSV
Flood Water
5fc4149
Equivilent Lengths (m)
6.3m
41.1m
47.4m
118.5m
165.9m
16.2m
182.1m
1.7m
183.8m
368.3m
552.1m
1326.2m
1878.3m
141m
2019m
126.6m
2145.6m
237.2m
2382.8m
JMC - 95/05/10 EAP_INS4.PPT
Rev. DJH 95/05/10, JMC 95/08/01
JMC 96/12/06

CHAPTER 2:

LITERATURE SURVEY

2.1: GENERAL CHARACTERISTICS OF FLUID MOTION IN ROUND PIPES

(Hildebrandt, 1982) explains that, the acoustic properties of round pipes with respect to the viscous and inertial forces of the fluid based on the (Rayleigh, 1945) work was investigated by him. To find out the behavior of a fluid motion in a round pipe, the extreme cases at low and high frequencies were looked at.

At the low acoustic frequencies or when the pipe diameter is very small, the viscous property of the fluid dominates the flow behavior (Hildebrandt, 1982). The mean velocity of the fluid is in proportion and in phase with the pressure gradient of the fluid. At the pipe wall, the flow velocity profile is zero (boundary condition) and at the center of the pipe, the fastest. The velocity profile shapes as an approximate parabola.

In the case of dealing with the high acoustic frequencies, the fluid motion will be affected by two factors:

The first factor is the inertia of the fluid. If the inertial forces dominate over the viscous forces, then the fluid motion lags behind the pressure gradient. If the pressure gradient varies harmonically, and the frequency increases, the velocity lag will approach 90°. Also the velocity profile flattens and the peak velocity decreases with increase in frequency. This physical situation is identical to a damper-mass system in the model (Fig. 1-3). In this model, for a constant applied force, the amplitude of vibration decreases as the frequency increases.

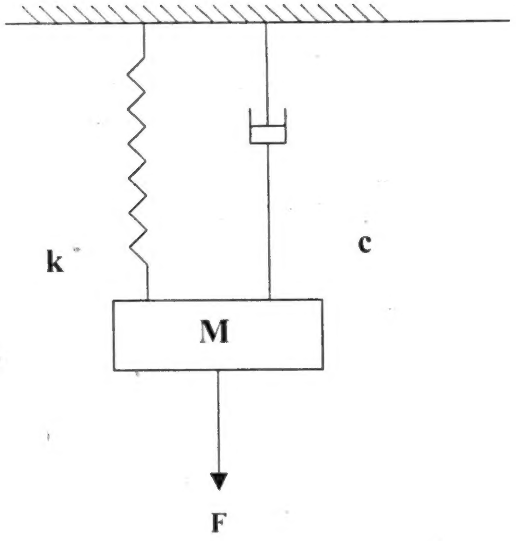


Figure 1-5: Damper-mass model for inertia of fluid

The second factor influencing the fluid motion is the heat conduction. At high frequencies, the heat of the fluid is not transmitted fast enough to the piping wall. As a result, the temperature of the fluid is not constant (non isothermal, $\Delta T \neq 0$). This in itself causes three following effects:

a) Speed of sound will approach the adiabatic speed of sound (for $\Delta Q = 0$), which is 343 m/s for air.

b) Since the piping wall has a lesser influence on the temperature of the fluid, there will be a significant temperature difference developed between the wall and the fluid at the axis direction of the pipe. As a result, the viscosity of the fluid will no longer be constant.

c) Dissipation effect comes into account, occurring in the fluid in the form of thermal processes. Even at high frequencies, viscous forces dominate the dissipation of the wave energy.

(Biot, 1956) developed a function to explain the interaction of the viscous and the inertial forces in the narrow channels and round pipes. His function was related to the momentum balance as shown. Based on that, the fluid velocity was taken to be constant across the pipe and was assumed to be equal to U:

$$-\frac{\partial P}{\partial X} = \rho_{e|k=0}\overline{U'} - F_{(k)}R_{|k=0}\overline{U} \qquad \text{(E2-1)}$$

That may be written as:

$$-\frac{\partial P}{\partial X} = \rho_{e}\overline{U'} - R\overline{U} \qquad \text{(E2-2)}$$

Where:

$\overline{U}$: Complex mean velocity, averaged across the pipe at $t = 0^\circ$ and $t = 90^\circ$ in the cycle

$\overline{U'}$: Time derivative of $\overline{U}$ along the pipe

ρ_e : The effective density

R : The resistivity (Kg/m^3s)

P : Pressure

It can be expected that the effective density and resistivity must vary with the change in frequency caused by contrasting the fluid motion characteristics at low and high frequencies. As an example, the damper-mass model shows that at high frequencies the magnitude of the velocity decreases (inverse relation). This indicates that the resistivity increases with frequency (direct relation). These properties that are the functions of frequency are also dependent on the type of pipe used.

2.2: CURRENT FORMULATION of CONSERVATION and BALANCE EQUATIONS for MULTIPHASE FLOW MODELING

There has been a considerable advance in the development of useful models for two-phase flows (Dobran, 1984). On the other hand, similar development for the three-phase flows has not been as rapid. The multiphase flow analysis is difficult because of their finite interfacial area. This fact has led to the diverse modeling approach, which is based on a continuum practice. (Dobran, 1984) wrote: "The conservation and balance equations of multiphase flows constructed in this manner are either postulated (Drumheller, 1980) (Sha, 1978), or they are obtained by an application of suitable averaging of the macroscopic field equations of each phase (Drew, 1971) (Marle, 1982)." Both approaches have deficiencies. The first one lacks a strong physical justification. The second one lacks reconciliation between the different levels of description.

The modeling of multiphase flows is based on one of the following approaches:

a) Using the single-phase multi-component mixtures equations and extending it to multiphase mixtures.

b) Averaging the instantaneous field equations of each phase over the needed time and space.

After an elaborated discussion (Dobran, 1984) explains each modeling approach and its limitation. He finally concludes that: "The theory of multiphase flows is in an infancy of development." And, "Clearly, while considerable progress has been made in the formulation of conservation, balance and constitutive equations for multiphase flows, much more work remains to be done in the future through both analysis and fundamental experiments."

CHAPTER 3:

GENERAL APPROACHES FOR THE THESIS

This thesis investigated a problem that involved exploring two different sound wave approaches, in order to determine the air (gas) content of the tar sand slurry in the pipeline. For the first approach, an audible sound wave was transmitted and linked to the resonance frequency of the slurry pipeline, to determine the amount of its air (or gas) content (active method). For the second approach, the methodology consisted of recording the flow noise of the slurry pipeline and relating its audible noise resonance to the air (gas) content in the flow (passive method). Some previous work (Ghazi, 1998) was done on a similar problem by conducting the pressure wave tests within the multiphase fluid loop.

CHAPTER 4:

RESONANT FREQUENCY TESTS

4.1: INTRODUCTION

If a sound wave (or pressure wave) is sent across the diameter of a pipe then: First harmonic of its resonance will occur as shown in (Fig. 4-1):

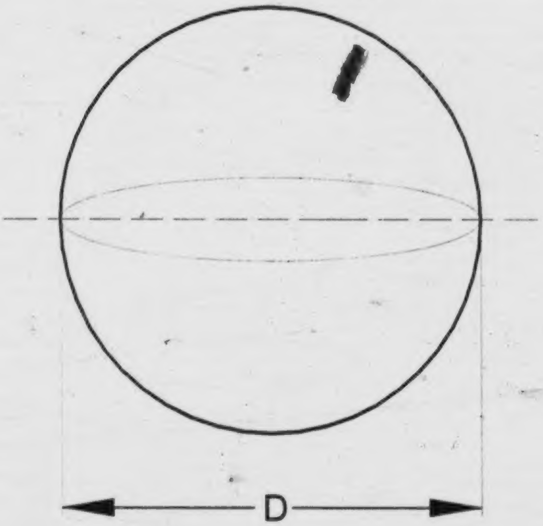


Figure 4-1 Schematic of First Harmonic across the Pipe

4.2: THEORETICAL DEVELOPMENT

In Fig. 4-1 for fluid harmonic:

$$\lambda_1 = 2D$$

$$f_1 = C / \lambda_1 = C / 2D$$

$$C = 2D f_1 \qquad \text{(E4-1)}$$

λ_1: First harmonics wave length, m

D: Diameter of the pipe, m

f_1: First harmonics frequency, Hz

C: Speed of sound in the slurry, m/s

Thus, if first harmonic resonance frequency of slurry content in the pipe is determined, the speed of sound in the pipe can be found (Serway, 1982, Coward, 1997&1998). Also It has been long time known that the speed of sound in the materials (C) including fluids may be calculated using the bulk modulus (B) and the density (ρ) of the material:

$$C^2 = B / \rho$$

Further the speed of sound in a multi phase slurry mixture within a pipe may be related to its different contents (air, liquid, solid), based on the following formula derived by (Shook, 1976).

$$1/C^2 = \rho_m.[\, \alpha_1 / B_1 + \alpha_2 / B_2 + ... + D / E_p.t \,] \qquad \text{(E4-2)}$$

ρ_m: Mixture density, Kg/m^3

α: Volumetric proportion

D: Pipe outer diameter, m

t: Wall thickness, m

B: Bulk modulus of material, Pa

E_p: Elastic modules of pipe, Pa

The air content can then be determined by finding out the speed of sound in slurry. To derive the above formula (Shook, 1976) assumed that the distribution of the dispersed phase was uniform. He also noted that: "Dispersed gases are presumed to obey some equilibrium pressure-volume relationship during pressure changes, such as that for ideal gases in isentropic processes. Surface or interfacial effects do not seem to be important because good agreement with experimental results is observed."

4.2.1: LITERATURE SURVEY

4.2.1.1: Acoustical Waves in a Homogeneous Mixture

(Wijngaarden, 1972) considered a homogeneous fluid with only some small gas bubbles in it for modeling. He assumed the process was to be isothermal (constant temperature), with possible compressibility of the bubbles in it. The other assumed conditions were to consider the bubbly character of the gas content, plus to consider the movement of gas and fluid should take place at the same velocity. For the properties of gas and fluid, "*g*" and "*f*" subscript were chosen, respectively. Let "β" to be the volume of gas within a unit volume of the bubbly fluid.

$$\beta = \frac{V_g}{V_f + V_g} = \frac{V_g}{1} = V_g \qquad \text{(E4-3)}$$

The density of the mixture ρ would be:

$$\rho = \rho_f(1-\beta) + \rho_g\beta \qquad \text{(E4-4)}$$

The mass of the gas in the unit mass of the mixture would be constant.

$$\frac{\rho_g\beta}{\rho_f(1-\beta)} = constant \qquad \text{(E4-5)}$$

Also p mixture is equal to p_g in the gas which is itself (for constant temperature), in proportion to ρ_g. Therefore:

$$\frac{p\beta}{\rho_f(1-\beta)} = constant \qquad \text{(E4-6)}$$

To find the sound velocity c, he wrote:

$$c^2 = \frac{dp}{d\rho} \tag{E4-7}$$

By substitution from equation (E4-4):

$$\frac{1}{c^2} = \frac{d\rho}{dp} = (1-\beta)\frac{d\rho_f}{dp} + (\rho_g - \rho_f)\frac{d\beta}{dp} + \beta\frac{d\rho_g}{dp}$$

With respect to equation (E4-7), and:

$$c_f^{\ 2} = \frac{d\rho_f}{dp}$$

$$c_g^{\ 2} = \frac{d\rho_g}{dp}$$

And neglecting $\rho_g^2 c_g^2/\rho_f^2 c_f^2$ with respect to unity, then:

$$\frac{1}{c^2} = \frac{(1-\beta)^2}{c_f^{\ 2}} + \frac{\beta^2}{c_g^{\ 2}} + \frac{\rho_f \beta(1-\beta)}{p} \tag{E4-8}$$

That shows that unless β is very close either to zero or unity, the speed of sound in the bubbly fluid will be lower than the speed of sound in the pure gas. For the other β magnitudes equation (E4-8) may be approximated to:

$$c^2 = \frac{p}{\rho_f \beta(1-\beta)} \tag{E4-9}$$

As an example, for $\beta=4\%$, and at atmospheric pressure, calculated c is only 50 m/s, which is much lower than either c_f or c_g.

4.3: METHODOLOGY AND RESEARCH OBJECTIVES

For this stage of the work the intention was to conduct an experiment to determine the resonance frequency of the proposed multiphase pipe loop that may be related to its amount of air content. That may be done by transmitting a proper range of the audible sound wave on one side of the pipe. The sound wave would travel across the diameter of the pipe that is perpendicular to the axes of the pipe and flow direction. Then amplifying, and displaying the received signal from the other side of the pipe and by means of an oscilloscope would indicate the resonance frequency of the pipe. The pipe may contain a flow of water, some low percentage of air (gas), and some solid particles in different test stages.

4.4: APPROACH FOR THE RESONANT FREQUENCY TESTS

A proper piping loop was designed and set up for the intended experiments. Then after the loop was refilled and a measured percentage volume of air content within the fluid was set up, an audible sound wave was transmitted at one side of the pipe, and the received signal from the other side was displayed on an oscilloscope. By investigating the received signal, the resonance frequency of the pipe and its content was identified and became interrelated to the fluid's air content percentage in the fluid.

4.5: TEST PROCEDURE

4.5.1: TEST SETUP

A rectangular shape closed loop of 38.1 mm diameter (1.5") clear PVC pipe and fittings was built. The overall length of the loop was about 9 meters. A centrifugal sewage type pump was part of the loop and was to be located at the corner of the loop (CP) (Figure 4-2). The pump was to handle slurries (particles) and was capable of maintaining a turbulent flow for a proper homogeneous blend. For that to happen, velocity of the flow had to be somewhat between 2.2 and 1.7 m/s, with respect to the Reynolds number and roughness of the pipe. For this project it was decided to have more than 3 m/s flow velocity design in order to select the pump. The selected 746 w (1 hp) pump had:

$Q = 0.00379\ \mathrm{m^3/s}$ capacity = 3.79 liters/s = 60 gpm

$H = 7$ m head = 10.2 psi

Length of the loop, $L = 9$ m

Pipe diameter, $D = 38.1$ mm = 0.0381 m

Density of water, $\rho = 1000\ \mathrm{kg/m^3}$

$g = 9.81\ \mathrm{m/s^2}$

$V = Q / A = (0.00379\ \mathrm{m^3/s}) / (\pi)(0.0307 / 2)^2$ (E4-10)

$V = 5.12$ m/s

$Re = DV / \nu$ (E4-11)

ν: Kinematic viscosity

ν: For water at 25 C is $0.893\times10^{-6}\ \mathrm{m^2/s}$, from table 4-1

$Re = (0.0307\ \mathrm{m})(5.12\ \mathrm{m/s}) / (0.893 \times 10^{-6}\ \mathrm{m^2/s}) = 2.18\times10^5$

$Re = 2.18 \times 10^5 >> 2400$

The result indicates that the flow would be very well within the turbulence range (Figure 4-2).

To find out the pressure drop within the designed loop:

$$P_1/\rho g + Z_1 + (V_1)^2/2g = P_2/\rho g + Z_2 + (V_2)^2/2g + H \qquad \text{(E4-12)}$$

$Z_1 = Z_2$ As there is no elevation change between the two points

$$(P_1 - P_2)/\rho g = H \qquad \text{(E4-13)}$$

And as:

$$H = f\,(L/D)(V^2/2g) \qquad \text{(E4-14)}$$

So:

$$(P_1 - P_2)/\rho g = f\,(L/D)(V^2/2g) \qquad \text{(E4-15)}$$

For PVC pipe, if the relative internal surface roughness is $e / D = 0.0003$, (Figure 4-2), then for Reynolds number 7.17×10^5 (5.12 m/s velocity), the resistance coefficient

$f = 0.015$

$P_1 - P_2 = (0.015)(1000\ \text{kg/m}^3)(9/0.0307\text{m})(5.12\ \text{m/s})^2/2$

$P_1 - P_2 = 57.6$ KPa = 8.4 psi Pressure drop expected around the loop

	Water		Air	
Temperature, ^{0}C	Viscosity, N.s/m^2	Kinematic Viscosity, m^2/s	Viscosity, N.s/m^2	Kinematic Viscosity, m^2/s
0	1.781×10^{-3}	1.785×10^{-6}	1.717×10^{-5}	1.329×10^{-5}
5	1.518×10^{-3}	1.519×10^{-6}	1.741×10^{-5}	1.371×10^{-5}
10	1.307×10^{-3}	1.306×10^{-6}	1.767×10^{-5}	1.417×10^{-5}
15	1.139×10^{-3}	1.139×10^{-6}	1.793×10^{-5}	1.463×10^{-5}
20	1.002×10^{-3}	1.003×10^{-6}	1.817×10^{-5}	1.509×10^{-5}
25	0.890×10^{-3}	0.893×10^{-6}	1.840×10^{-5}	1.555×10^{-5}
30	0.798×10^{-3}	0.800×10^{-6}	1.864×10^{-5}	1.601×10^{-5}
40	0.653×10^{-3}	0.658×10^{-6}	1.910×10^{-5}	1.695×10^{-5}
50	0.547×10^{-3}	0.553×10^{-6}	1.954×10^{-5}	1.794×10^{-5}
60	0.466×10^{-3}	0.474×10^{-6}	2.001×10^{-5}	1.886×10^{-5}
70	0.404×10^{-3}	0.413×10^{-6}	2.044×10^{-5}	1.986×10^{-5}
80	0.354×10^{-3}	0.364×10^{-6}	2.088×10^{-5}	2.087×10^{-5}

Table 4-1: Kinematic Viscosities (ν) of Water and Air

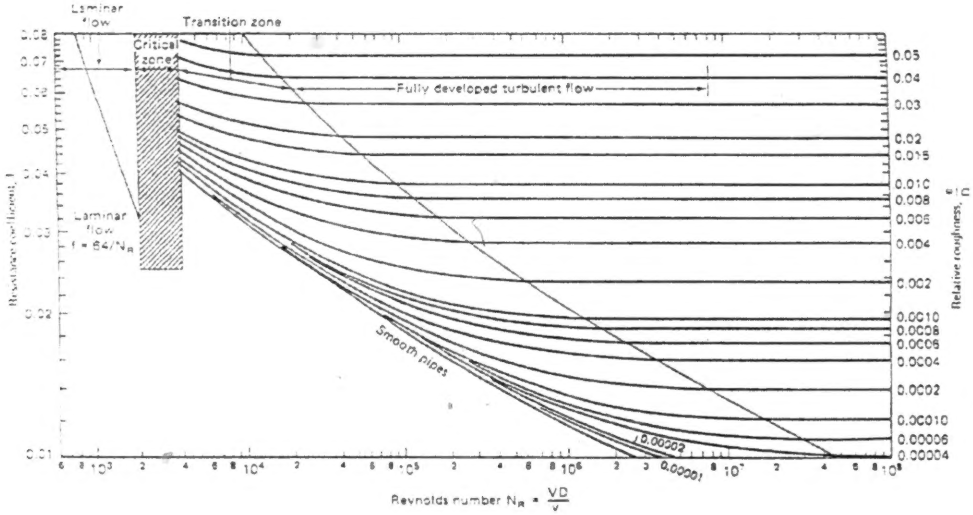


Figure 4-2 Laminar, turbulent flow and Reynolds number

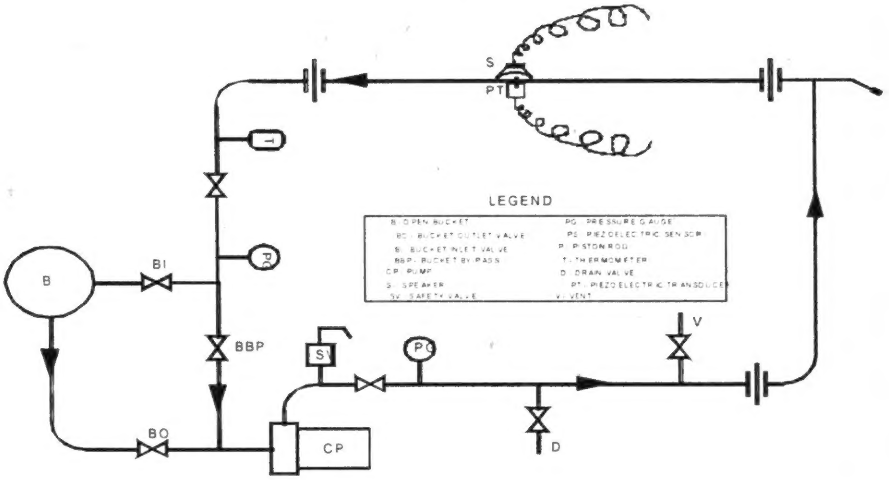

S
PT
T
PG
B
BI
BBP
SV
PG
V
BO
CP
D
LEGEND
B - OPEN BUCKET
BO - BUCKET OUTLET VALVE
BI - BUCKET INLET VALVE
BBP - BUCKET BY-PASS
CP - PUMP
S - SPEAKER
SV - SAFETY VALVE
PG - PRESSURE GAUGE
PS - PIEZOELECTRIC SENSOR
P - PISTON ROD
T - THERMOMETER
D - DRAIN VALVE
PT - PIEZOELECTRIC TRANSDUCER
V - VENT

Figure 4-3 **Experimental Tests Loop**

Refilling and venting the loop was done through the bypass valves, pipes, and the side bucket (B). To drain the loop valve (D) was used to let off a specified amount of water. This amount was replaced by the air infiltrated into the pipe through valve (D) (Fig. 4-2).

4.5.2: WHAT WAS TO BE MEASURED?

As it was mentioned earlier in the objectives of the project, the resonance frequency of the pipe and its content was to be measured. The result then could be linked to the amount of air content within the flow.

4.5.3: REFILLING AND DRAINING THE PIPE LOOP SYSTEM

The system (Fig. 4-2) was to be refilled through an open bucket (B). The pump (CP) was to be used to direct any unwanted air to the bucket, gradually through the connection valve (BI). The complete refilled loop could be drained through the drain (D) valve into a measuring bucket. The purpose for this initially was to measure the exact volume of the loop. In order to introduce any desired percentage of the air into the loop, all that was required was a water-filled system by the amount of volume chosen. Afterward, air entered into the loop would be made to replace the drained water along the drain line.

4.5.4: HOW THE MEASUREMENT TOOK PLACE?

The system was started up with a measured volume of fluid and air, and run for a few minutes in order to obtain a proper turbulent blend, as well as to bring it to its steady state homogeneous fluid flow condition. At this point all the instruments for measurement were connected to the loop (Fig. 4-3) and were energized. The signal generator was set to the sine wave, and its knob was turned slowly to change its frequency. The generated sound was broadcast from the speaker (S), and passed through the PVC pipe and its moving fluid. The Piezoelectric pressure transducer (PT) received the sound signal through its conditioner, and sent it to the scope to display. The observation indicated that at the first resonance frequency, the displayed graph got excited and its width along the Y-axis broadened. At this time the corresponding frequency was recorded.

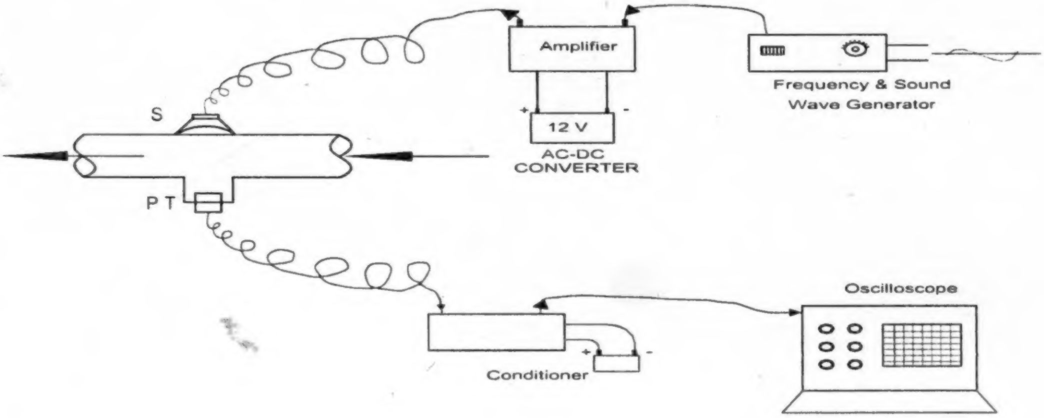

Amplifier
Frequency & Sound
Wave Generator
S
+
-
12 V
AC-DC
CONVERTER
P T
Oscilloscope
+
-
Conditioner

Fig. 4-4: Instrumentation Hook up for the Loop

As an example: For the 1.5" PVC pipe loop that is filled with 100% water, the speed of sound could be calculated by the Shook's equation as (Ghazi, 1998):

$$1/C^2 = \rho_m (\alpha_w / B_w + D / E_p t) \qquad \text{(E4-16)}$$

Physical properties for some common materials are given in (Table 4-2):

Material	V_{sound} (m/s)	d (Kg/m^3)	Bulk Modu. (MPa)	Elast. Modu. (MPa)
Air	331	1.293	0.141662	
Bitumen	1350	995	1813.4	
Poly Ethylene	443	1050	206	
Water	1496	1000	2100	
PVC	1448	1400		2937
Quarts	5900	2200	36542	71705
Steel	5940	7840	160000	203395

Table 4-2: Physical properties for some common materials

(Baumeister 1978 , Lide 1991)

Note: Bulk modulus of elasticity of a fluid (B) (different from modulus of elasticity, E) is the ratio of the pressure stress to the volumetric strain (its unit is Pa)

$$1/C^2 = (1000\ \text{kg/m}^2)\ [1/2100\text{x}10^6\ \text{Pa} + (38.1\ \text{mm}) / (2.937\text{x}10^9\ \text{Pa})(3.68\ \text{mm})]$$

$$C = 500\ \text{m/s}$$

For an amount of 0.1% (by volume) air content in the same 1.5" diameter PVC (Polyvinyl Chlorine) pipe, the calculation would be:

$$1/C^2 = \rho_m (\alpha_a / B_a + \alpha_w / B_w + D / E_p t) \qquad \text{(E4-17)}$$

$\alpha_a = 0.001$, $B_a = 0.14166\text{x}10^6$ Pa

$\alpha_w = 0.999$, $B_w = 2100\text{x}10^6$ Pa

$D = 38.1$ mm, $E_p = 2937\text{x}10^6$ Pa, $t = 3.68$ mm

$$\rho_m = \rho_a \alpha_a + \rho_w \alpha_w \tag{E4-18}$$

$\rho_a = 1.293\ \mathrm{kg/m^3}$, $\quad \rho_w = 1000\ \mathrm{kg/m^3}$

$\rho_m = 1.293 \times 0.001 + 1000 \times 0.999 = 999.001\ \mathrm{kg / m^3}$

$1/C^2 = 999.001\ (0.001/0.14166\mathrm{x}10^6 + 0.999/2100\mathrm{x}10^6 + 38.1/3.68\mathrm{x}2.937\mathrm{x}10^9)$

$C = 300.84\ \mathrm{m / s}$

The calculation shows that the effect of a small amount of air content (0.1% by volume) on the speed of sound in the mixture of water and air flowing in the pipe is very dramatic; because it caused the speed to drop from 500 m/s down to 300.84 m/s.

In another example, for the 3.8 cm (1.5 inch) PVC pipe that was filled by volume percentage of 94.9% water, 5% beads (Polyethylene dyed with graphite), and 0.1% air, the speed of sound by the Shook's equation may be calculated as:

$$1/C^2 = \rho_m (\alpha_w / B_w + \alpha_e / B_e + \alpha_a / B_a + D / E_p t) \tag{E4-19}$$

$$\rho_m = \rho_w \alpha_w + \rho_e \alpha_e + \rho_a \alpha_a \tag{E4-20}$$

$\rho_e = 1050\ \mathrm{kg/m^3}$

$E_e = 206 \times 10^6\ \mathrm{Pa}$

$\rho_m = 1000 \times 0.949 + 1050 \times 0.05 + 1.293 \times 0.001 = 1001.5$

$1/C^2 = (1001.5\ \mathrm{kg/m^3})\ [0.949/2100\mathrm{x}10^6\ \mathrm{Pa} + 0.05/206\mathrm{x}10^6\ \mathrm{Pa} +$

$\qquad 0.001/0.14166\mathrm{x}10^6 + (38.1\ \mathrm{mm}) / (2.937\mathrm{x}10^9)(3.68\ \mathrm{mm})] = 1.1 \times 10^{-8}$

$C = 300.79\ \mathrm{m/s}$

That means the Time Of Flight (TOF) of sound wave across the pipe tee fitting (11 cm) will be somewhere between 0.2 to 0.4 milliseconds. The instrument was used to capture the signal for measurement was a piezoelectric pressure transducer. Its sensitivity was capable of handling the sound velocity of 500 m/s or even less.

The expected sound velocity within the air water mixture at the 1.5" PVC pipe loop may be calculated as below (Table 4-3):

Sound Speed PVC 1.5" Pipe (Air, Water) Shook

B_a (P_a)	1.4166E+05	D (mm)	38.1	d_a (kg/m^3)	1.293
Bw (P_a)	2.1000E+09	t (mm)	3.68	dw (kg/m^3)	1000
Ep (P_a)	2.9370E+09				

Air%	Air Vol.	1/C^2	C (m/se)
0	0	4.0013E-06	499.92
0.05	0.0005	7.5269E-06	364.50
0.1	0.001	1.1049E-05	300.84
0.15	0.0015	1.4567E-05	262.00
0.2	0.002	1.8082E-05	235.16
0.25	0.0025	2.1594E-05	215.20
0.3	0.003	2.5102E-05	199.59
0.5	0.005	3.9098E-05	159.93
0.8	0.008	5.9988E-05	129.11
1	0.01	7.3843E-05	116.37
2	0.02	1.4228E-04	83.84
3	0.03	2.0930E-04	69.12
4	0.04	2.7491E-04	60.31
5	0.05	3.3911E-04	54.30

Table 4-3: Speed of sound in 1.5" PVC pipe

Using the data in the above table, the plot of theoretical resonance frequencies of the 38 mm (1.5") PVC pipe with air content in the 0% to 100% range (Figure 4-5) could be drawn. The expected sound speed through the fluid may be calculated by the Shook's equation (Ghazi, 1998). As the plotted graph demonstrates, the maximum resonance frequency of the pipe is 2272.36 Hz, which occurs at 0% air content. On the other hand, air content of 50% will result in the minimum resonance frequency of 108.7 Hz of the pipe.

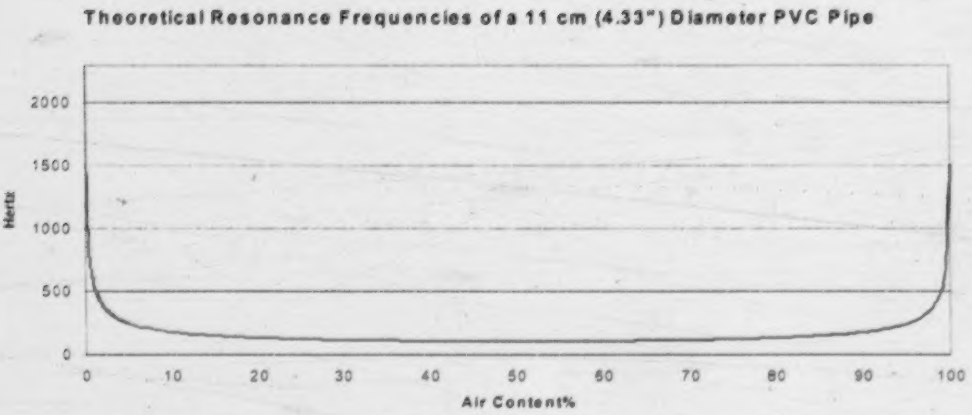

Theoretical Resonance Frequencies of a 11 cm (4.33") Diameter PVC Pipe
2000
1500
1000
500
0
Hertz
0
10
20
30
40
50
60
70
80
90
100
Air Content%

Figure 4-5

4.6: EXPERIMENTATION

4.6.1: PIPING LOOP SET UP AND INITIAL EXPERIMENTATION

After the designed PVC piping loop was assembled, the loop was filled with clean tap water through its bucket (B)(Fig. 4-2). The pump that was selected had a 746 W (1 hp) three-phase motor. By using a Variable Frequency Drive (VFD) power supply, the pump could be run at various speeds and powers. Once the pump was running, the air bubbles were forced to enter the bucket (B) by throttling the (BBC) and (BI) valves moderately. Then the air bubbles were directed upward to the water surface with an elbow and nipple. The pump suction was designed to withdraw water from a lower port of the bucket, which would be bubble free (BO valve).

To remove all the air, a speed of 45 Hertz at the VFD was needed. The velocity of circulating water caused the movement of the bubbles from the clear PVC pipe loop and into the bucket (B). In about four minutes, all the bubbles in the loop were visually removed from the water and vented out through the bucket. At this point, no bubbles could be seen circulating through the clear PVC piping. Then, the bypassing valve at the bucket side (BBP) was opened up and the valves connected to the bucket were turned off (BI & BO).

For the three-phase fluid flow test (water, air and beads), some fabric screens were installed at the inlet and outlet piping to and from the bucket and at the drain valve (D), in order to entrap the beads within the pipe.

4.6.2: EXPERIMENTATION WITH THE FULL LOOP

The condition for the first test consisted of starting up the pump and throttling up its frequency to the maximum of 55 Hz. At this point the conditioner for the Piezoelectric transducers sensors (PS) (Fig. 4-2), which was battery operated, had to be turned on. It was also necessary to turn on the oscilloscope and to make the required adjustment at one of its input channels, because there was only one input signal.

To introduce a measured percentage volume of the air into the full loop, it was necessary to measure the volume of the moving part of the fluid in the loop. This was done by draining the water from filled loop and measuring it, as well as calculating the volume of the sections that were not drainable, such as the bottom half of the pump volute casing. As a result, the effective volume of the moving fluid within the loop was determined and found to be 14,230 cm^3.

4.7: TEST RESULTS AND INTERPRETATION

4.7.1: FOR TWO PHASE FLUID (WATER AND AIR)

A total of 216 sound wave resonance tests were performed on the loop. Each test categorized a different percentage of the water and air mixture, which was tested at different speeds of the pump (RPM). According to Dr. Coward's suggestion, the air percentage ranged from 0% to 5%, in order to replicate the approximate variable range of air content within the tar sand slurry pipeline at Syncrude mines. These tests were done twice at different RPMs (3190, 2900, 2610, 2320, 2030, 1740, 1450, 1160, 870, 580, 290) by varying the frequency of the power supply to the pump at the VFD panel. Care was taken to test only on non-segregated (homogeneous) flow.

Enforcing the required constrains of non-segregated criteria, and for the different percentage of the air content, the different range of RPM of the circulating pump that would be acceptable were:

- For the 5% air content, range of 3190 down to 2610 RPM
- For the 4% air content, range of 3190 down to 2320 RPM
- For the 3% air content, range of 3190 down to 2030 RPM
- For the 2% air content, range of 3190 down to 1740 RPM
- For the 1% air content, range of 3190 down to 1740 RPM
- For the 0.8% air content, range of 3190 down to 1740 RPM
- For the 0.5% air content, range of 3190 down to 1450 RPM
- For the 0.3% air content, range of 3190 down to 1160 RPM
- For the 0.25% air content, range of 3190 down to 1160 RPM
- For the 0.2% air content, range of 3190 down to 580 RPM
- For the 0.15% air content, range of 3190 down to 290 RPM
- For the 0.1% air content, range of 3190 down to 290 RPM
- For the 0.05% air content, range of 3190 down to 290 RPM
- For the 0% air content, range of 3190 down to 290 RPM

The data was grouped according to the fixed RPM of the pump:

In order to show the discrepancies between the test results and the theoretical calculation, the theoretical expected curves and the experimental result were plotted together (Figure 4-6 to 4-17).

Each test could be considered as taken in an approximate isothermal condition. Given the time it took to record the gages for each sound wave event around the loop (1.5 minutes), the moving fluid (14 liters) only indicated one or two decimal point of degree Centigrade change.

In general, all the figures show some small discrepancies between 0.2% up to the 1% of the air content in the fluid. These could be attributed to a combination of the factors below:

1. Minor error in measurement of the mixture volume
2. Visual error in picking up the resonance condition on the scope display
3. Sensitivity effect of all the instruments involved and the gauge readings
4. Release of dissolved air due to a rise in temperatures by a few degrees during a group of tests taken in a row
5. The Pizoelectric transducer receiver had to be screwed into the side of a tee fitting, which make the receiver to be offset by about 3.5 cm from the side of pipe.
6. For the calculation purposes, it was assumed that the Pizoelectric Transducer receiver was installed on an 11 cm diameter pipe (Fig. 4-3).
7. The cross sectional of the PVC pipe would have expanded due to the varied internal pressure. The largest internal pressure numbers recorded were:

   Discharge pressure = 5.9 PSI = 40.69 KPa

   Suction pressure = 1.3 PSI = 8.97 Kpa
8. Compressibility effect of the air content due to the varied internal loop pressure

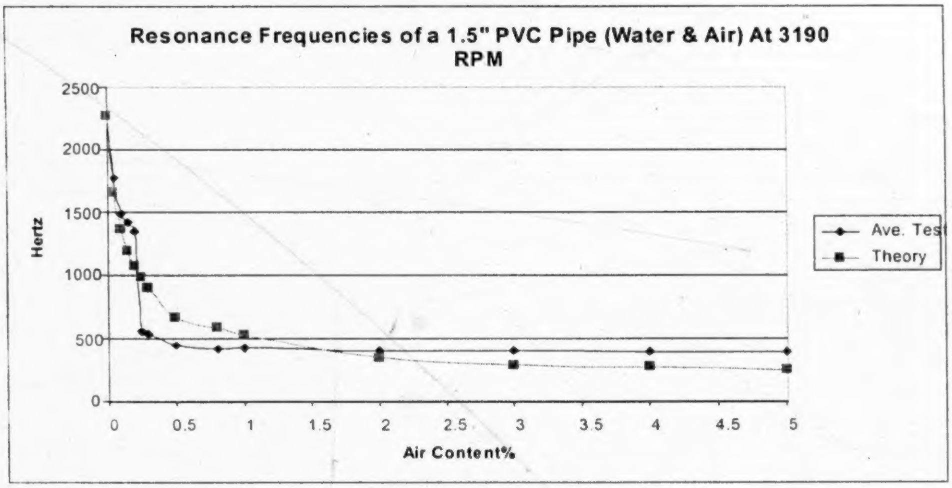


Figure 4-6

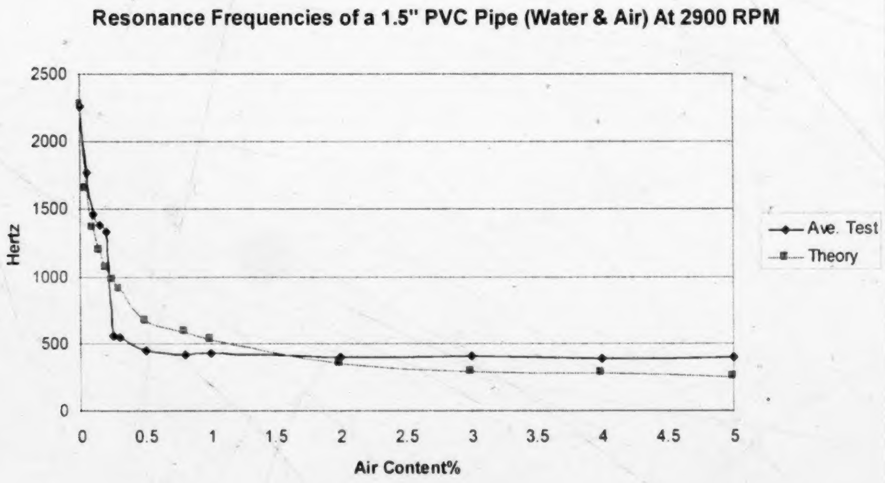


Figure 4-7

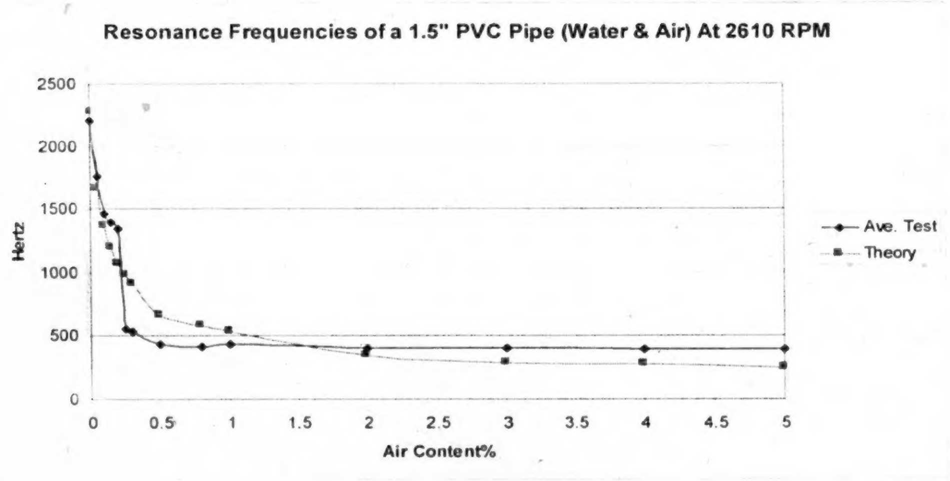


Figure 4-8

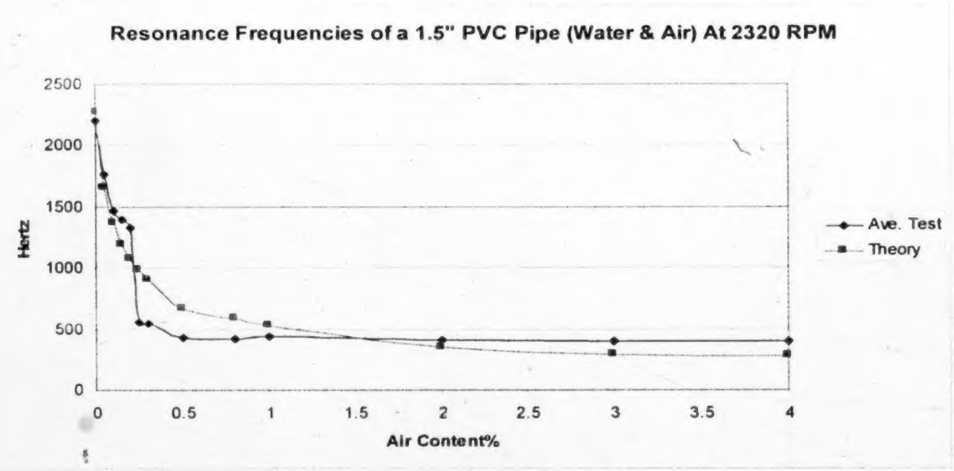


Figure 4-9

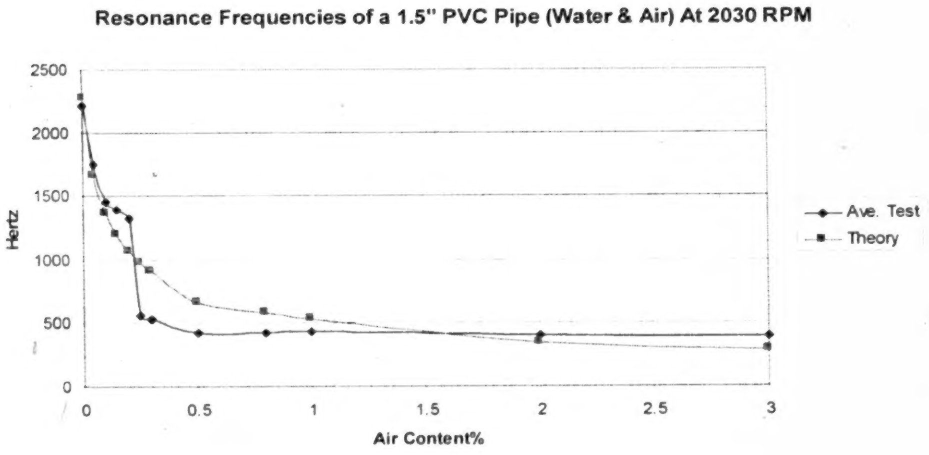


Figure 4-10

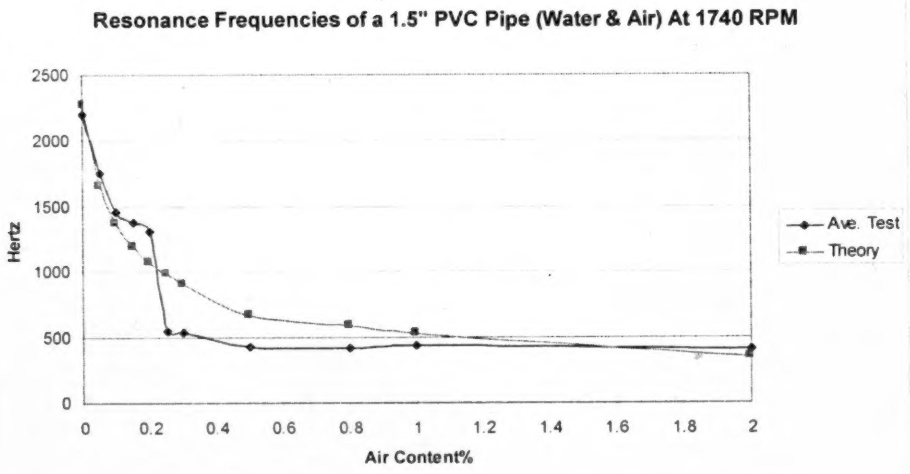


Figure 4-11

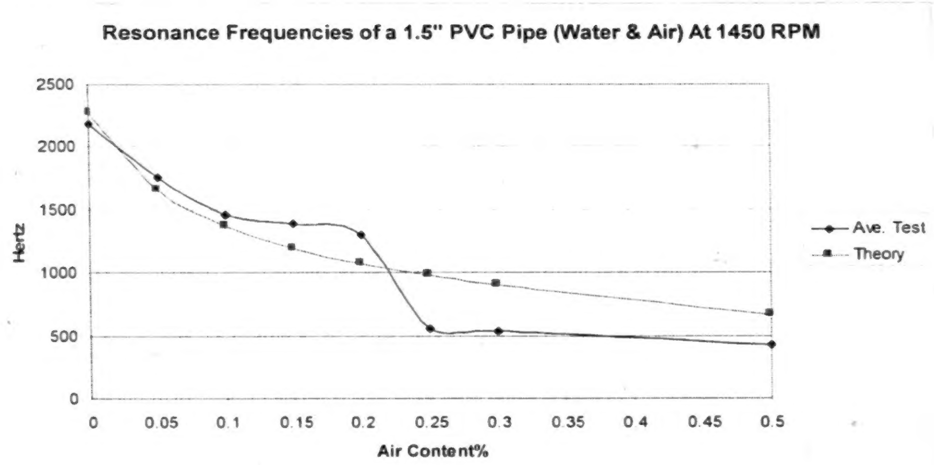


Figure 4-12

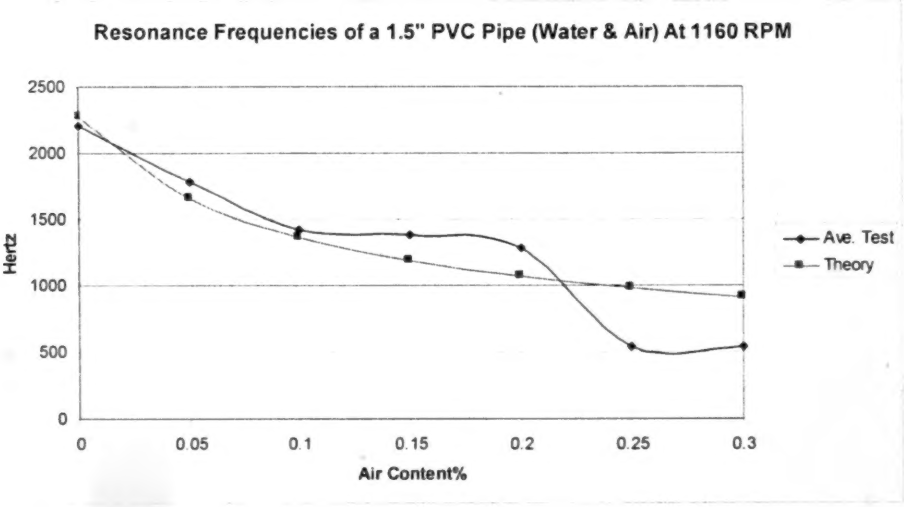


Figure 4-13

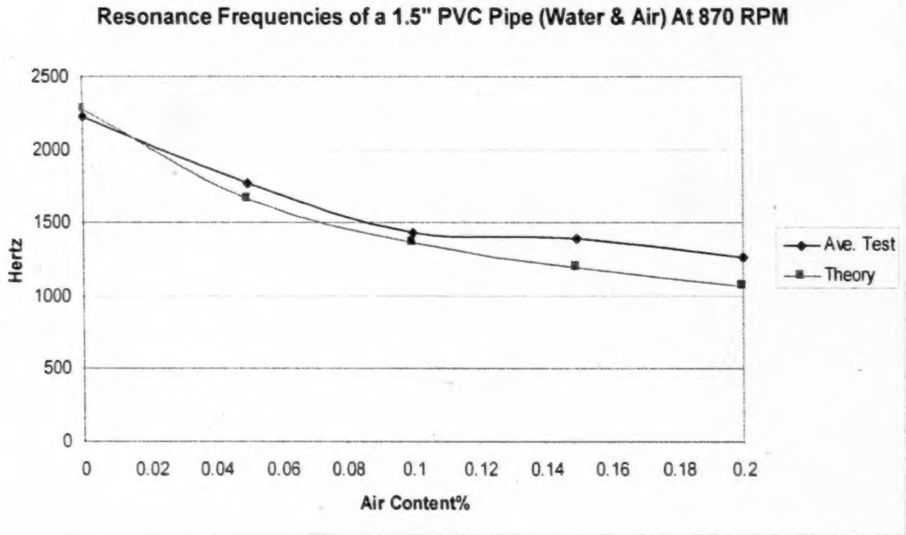


Figure 4-14

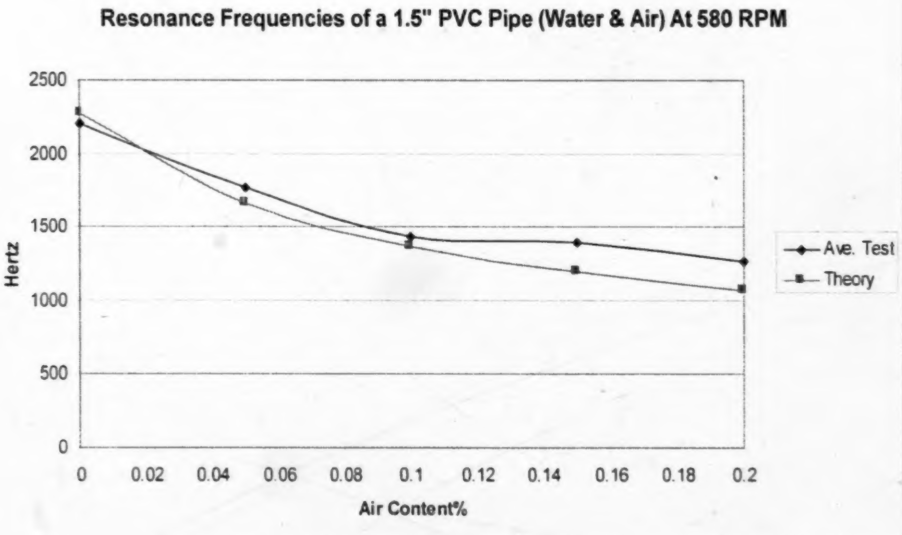


Figure 4-15

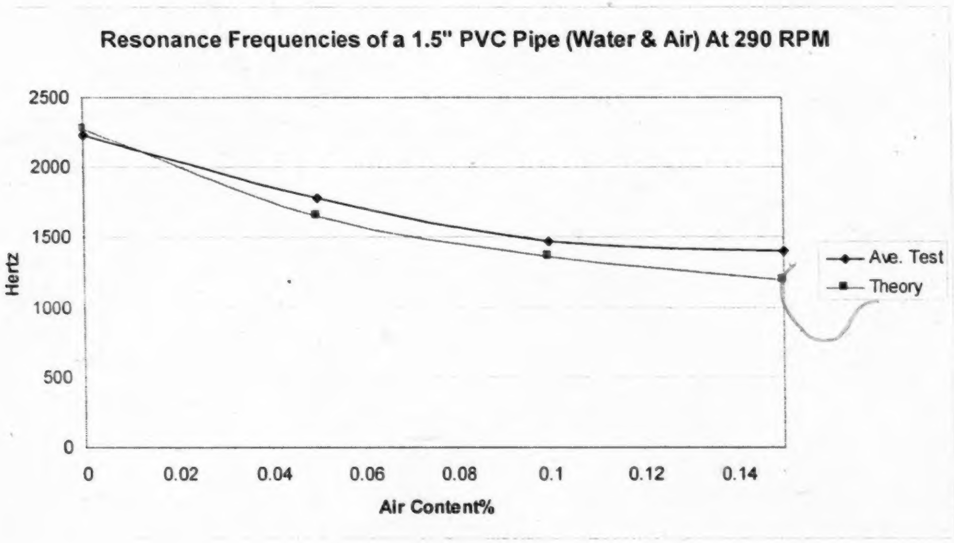

Resonance Frequencies of a 1.5" PVC Pipe (Water & Air) At 290 RPM
2500
2000
1500
1000
500
0
Hertz
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Air Content%
Ave. Test
Theory

Figure 4-16

The data also averaged at each air percentage in the fluid mixture (Figure 4-17). Again, the figure shows some small discrepancies within range of 0.2% to 1% of the air content in the fluid.

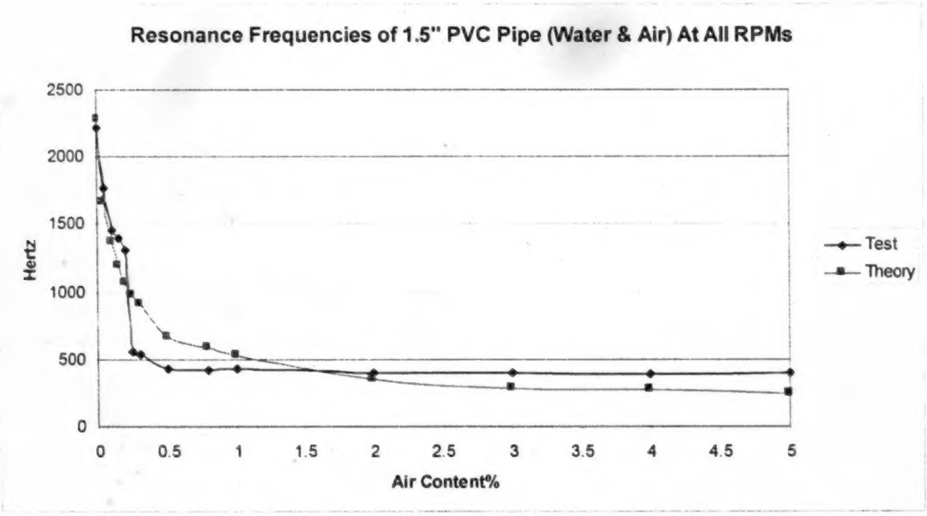


Figure 4-17

The last figure in this group summarized all the two-phase results in a single sheet (Figure 4-18). On the figure, the first Y-axis on the left was to scale the tested resonance frequencies in the 1.5 inches (3.8 cm) PVC pipeline, in Hertz. The second Y-axis on the right was to scale the corresponding RPM of the pump accordingly. The horizontal long bars across each group of the tests were to present the calculated theoretical resonance frequencies in each of the mixed fluids, according to the percentage of the air content in that fluid.

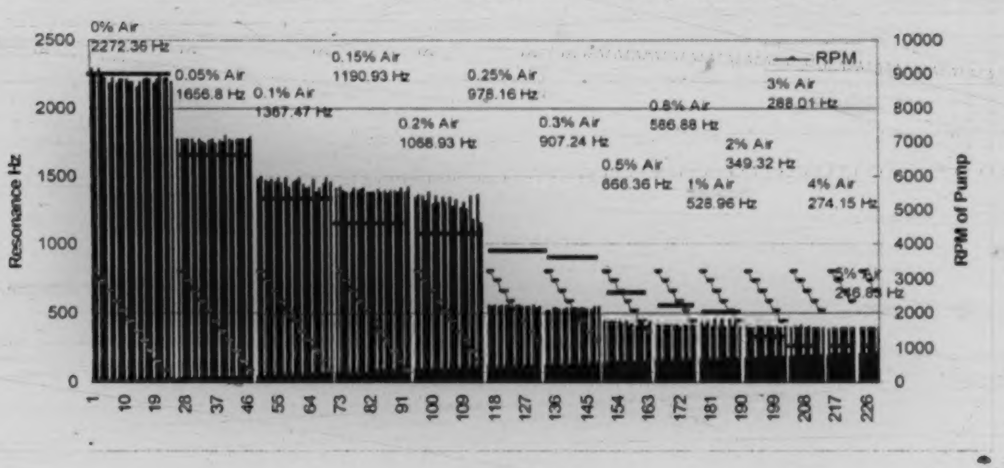

Tested Resonance Frequencies of a 1.5" PVC Pipe (Water & Air)
Resonance Hz
RPM of Pump
RPM
0% Air
2272.36 Hz
0.05% Air
1656.8 Hz
0.1% Air
1367.47 Hz
0.15% Air
1190.93 Hz
0.2% Air
1068.93 Hz
0.25% Air
978.16 Hz
0.3% Air
907.24 Hz
0.5% Air
666.36 Hz
0.8% Air
586.88 Hz
1% Air
528.96 Hz
2% Air
349.32 Hz
3% Air
288.01 Hz
4% Air
274.15 Hz
5% Air
0
500
1000
1500
2000
2500
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
1
10
19
28
37
46
55
64
73
82
91
100
109
118
127
136
145
154
163
172
181
190
199
208
217
226

Figure 4-18

4.7.2: FOR THREE PHASE FLUIDS (WATER, AIR, AND SOLID)

A total of 42 sound wave tests on the loop were performed. For each test, a figure was made and the resonance frequency of the pipe was calculated and compared with the experimental result. The new total volume of the loop system was 17,910 cm^3 as the pump was replaced and the piping around it was modified. Each test categorizes a fixed volume of 5% Poly Ethylene beads (895.5 cm^3, by volume). The air percentage volume for the tests was 0%, 0.05%, and 1%. These tests were done twice at different RPMs (2700, 2400, 2100, 1800, 1500, 1200, 900) by using the VFD (Variable Frequency Drive). Care was taken to test only on non-segregated moving fluid.

Because the tests were conducted on the mixtures with the three specified air contents, all that was needed was to average the resonance frequency results. That may create a single figure with three scattered points as the average of the test results. In order to show the discrepancies with the Shook's equation and other theoretical assumptions, an overlapped figure (Figure 4-19) was made out. The figure indicates some discrepancies between the tested points and the theoretical expectation:

1- At 0% air content, measured resonance was 1966 Hz in comparison with the expected theoretical resonance of 2203.9 Hz. The theory suggested that there was 0.016% of air volume (2.9 cm3) within the loop.

2- At 0.05% air content, measured resonance was 1441 Hz in comparison with the expected theoretical resonance of 1631.2 Hz. The theory suggested that there was 0.081% of air volume (14.5 cm^3) within the loop.

3- At 0.1% air content, measured resonance was 1181 Hz in comparison with the expected theoretical resonance of 1352.4 Hz. The theory suggested that there was 0.15% of air volume (26.8 cm^3) within the loop.

Again each test could be considered to have been taken in an approximate isothermal condition. That was due to the volume of the loop that was about 18 liters and the time taken to record all the readings around the loop, which took about 1.5 minutes. For each reading period, the loop temperature did not have a chance to change more than one or two decimal points of a Centigrade degree.

In general, the figure shows some discrepancies between the actual readings and the theoretical expectation. Part of the problem could be caused by the air bubbles stuck to the grain beads of the Poly Ethylene (solid). It was not practically possible to eliminate fully the air bubbles.

The other possible reasons for the minor discrepancies are already listed during the test results and interpretation of the two-phase fluids.

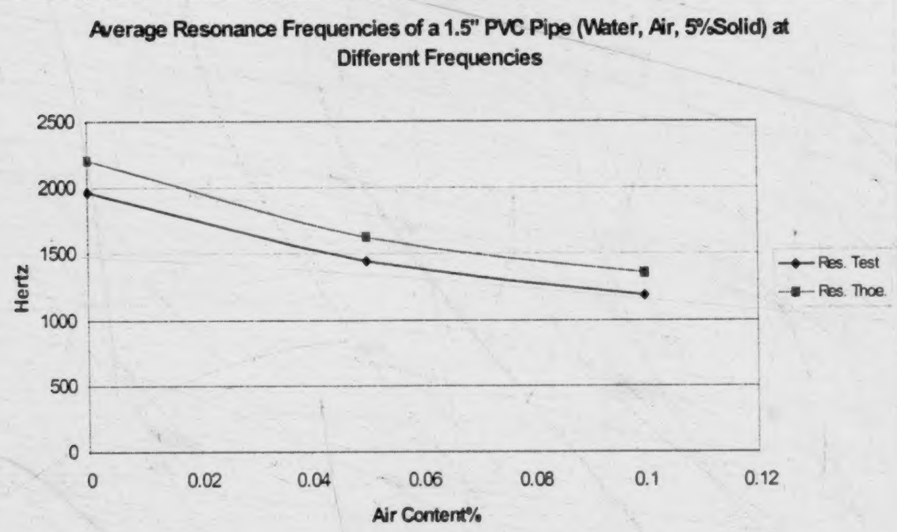

Average Resonance Frequencies of a 1.5" PVC Pipe (Water, Air, 5%Solid) at Different Frequencies
Hertz
2500
2000
1500
1000
500
0
0
0.02
0.04
0.06
0.08
0.1
0.12
Air Content%
Res. Test
Res. Thoe.

Figure 4-19

The next figure was designed to plot the expected theoretical resonance frequencies of the 38 mm (1.5") PVC pipe with fixed solid content of 5% by volume and variable air content between 0% up to 95% (Figure 4-20). As the plot suggests, the maximum resonance frequency of such loop happens at 0% air content and is 2209.9 Hz. On the other hand, the minimum resonance frequency of the same loop happens at air content ranging from 49% to 51% and calculated to be 107.8 Hz.

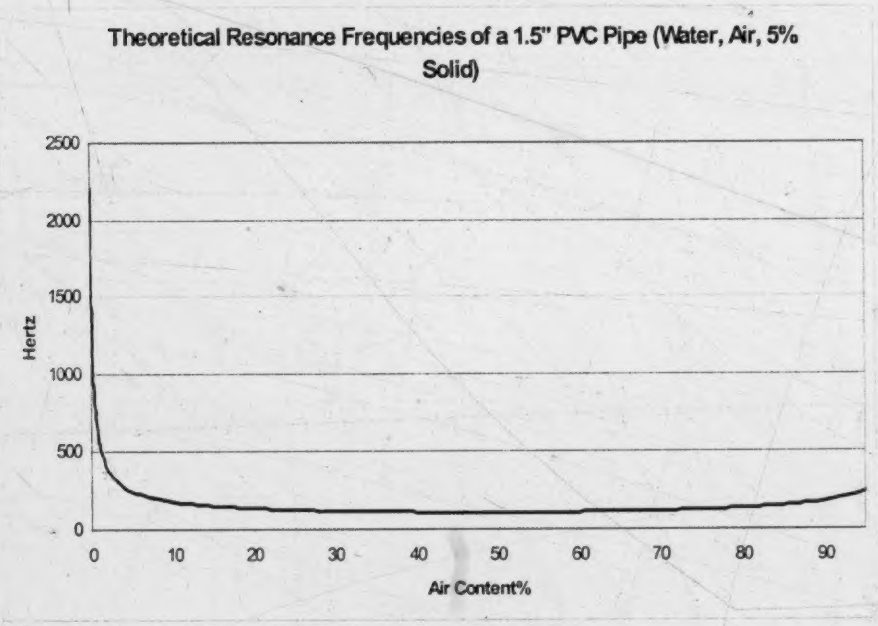
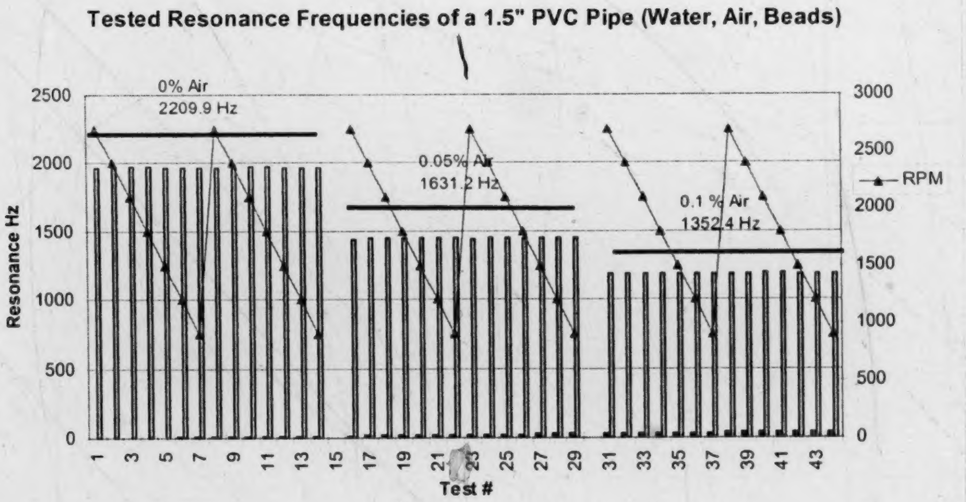


Figure 4-20

The last figure in this group was created to summarize the results of all the three phases in a single sheet (Figure 4-21). On the figure, the first Y-axis was to scale the tested resonance frequency in the 1.5 inches (3.8 cm) PVC pipeline, in Hz. The second Y-axis located at right hand side of the figure, and was to scale the rated RPM of the pump accordingly. The horizontal bars across each group of the tests were to present the calculated theoretical resonance of the pipe according to the percentage of the air-content in that fluid.



Tested Resonance Frequencies of a 1.5" PVC Pipe (Water, Air, Beads)
0% Air
2209.9 Hz
0.05% Air
1631.2 Hz
0.1 % Air
1352.4 Hz
RPM
Resonance Hz
2500
2000
1500
1000
500
0
3000
2500
2000
1500
1000
500
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
Test #

Figure 4-21

4.8: CONCLUSION TO THE RESONANT FREQUENCY TESTS

Analysis of the results of 258 resonance tests done in this part of the experiments proved that the speed of sound equation in a multi phase slurry mixture derived by Shook (Shook, 1976) was valid.

$$1/C^2 = \rho_m . [\alpha_1 / E_1 + \alpha_2 / E_2 + ... + D / E_p . t] \qquad \text{(E4-21)}$$

However, some small discrepancies of up to 1% air content existed in the mixture. Experiments also showed that the speed of sound in the slurry was very sensitive to the amount of air content. In comparison, the speed of sound was slightly sensitive to the solid content within the slurry flow.

It was also found that the speed of sound changes the most when percentage of air content is very low (up to 1%). On line and instantaneous monitoring of air content in oil sand slurries will be a significant contribution to the science of the slurry flow in large diameter installations.

CHAPTER 5:

NOISE SPECTRUM TESTS

5.1: INTRODUCTION

Noise level spectrum of the tar sand slurry flow in the pipelines at the North Mine and Aurora Mine may be measured and recorded. The result may then be investigated to determine natural resonance frequencies of the slurry flow, which can be related to the air content in the slurry flow.

5.2: THEORETICAL DEVELOPMENT

5.2.1: SOUND LEVEL MEASUREMENT

The range of sound amplitudes is very great and it is common to express the sound pressure by the logarithmic scale, in decibels (Dowling, 1983). The sound pressure level (SPL) is a mean square level of fluctuation and is defined by convention as:

$$SPL = 20\log_{10}\left(\frac{p'_{rms}}{0.0002\mu bar}\right) = 10\log_{10}\left(\frac{p'_{rms}}{p_{ref}}\right)^2 \qquad \text{(E5-1)}$$

$$SPL = 20\log_{10}\left(\frac{p'_{rms}}{2x10^{-5}\,N/m^2}\right) = 20\log_{10} p'_{rms} + 94$$

Where: $p'^2_{rms} = p'^2_{average}$

The international reference pressure of (2×10^{-5} Pa for airborne sound and 10^{-6} Pa for underwater sound) is average threshold of hearing by young adults when listening to a pure tone of 1000 Hz (Bell, 1982). The typical sound levels in an everyday exposure are as shown below (1 atm = 14.69595 psi = 101.325 kPa):

0 dB = 3×10^{-9} psi = 2.07×10^{-5} Pa:	Threshold of hearing
20 dB = 3×10^{-8} psi = 2.07×10^{-4} Pa:	Whisper
40 dB = 3×10^{-7} psi = 2.07×10^{-3} Pa:	Quiet residential neighborhood
60 dB = 3×10^{-6} psi = 2.07×10^{-2} Pa:	Normal speech
80 dB = 3×10^{-5} psi = 2.07×10^{-1} Pa:	Busy office
100 dB = 3×10^{-4} psi = 2.07 Pa:	Canning plant, Heavy city traffic, Subway

120 dB = 3 x 10^{-3} psi = 2.07 x 10 Pa:	Discotheque
140 dB = 3 x 10^{-2} psi = 2.07 x 10^{2} Pa:	Large propeller aircraft, Air raid siren, Riveting and chipping
160 dB = 3 x 10^{-1} psi = 2.07 x 10^{3} Pa:	Medium jet engine

The available instruments in the market to measure the sound level are included:

- Sound Level Meter
- Integrating Sound Level Meter (ISLM)
- Noise Dosimeter

Using the Sound Level Meter (SLM), readings in the different Octave band frequencies (spectrum) may be measured in decibel (L_n, n =1,2,3,...). The total composite sound level then may be calculated by the following formula:

$$\text{Total L} = 10 \log [\Sigma 10^{Ln/10}] \tag{E5-2}$$

$$\text{Total L} = 10 \log [10^{L1/10} + 10^{L2/10} + 10^{L3/10} + \ldots + 10^{Ln/10}]$$

That may be schematically denoted by (Pierce, 1981):

$$L = L_1 \oplus L_2 \oplus L_3 \oplus L_4 \oplus \cdots \oplus L_n$$

For the combination of the two levels, equation (E5-1) may be used:

$$L_1 \oplus L_2 = L_2 + C_+ (L_2 - L_1) = L_2 + C_+ (\Delta L)$$

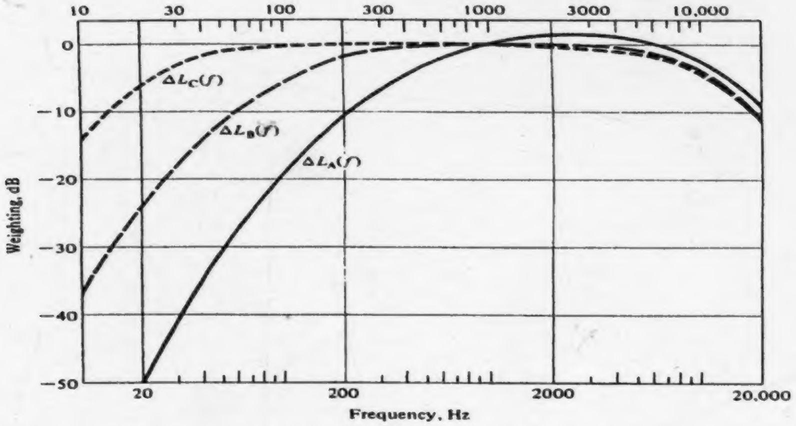
$$C_+ (\Delta L) = 10 \log (1 + 10^{-\Delta L/10})$$

$C_+ (\Delta L)$ is called *decibel addition function*.

L_2 is always to be considered larger than L_1 (if needed, interchange L_2 and L_1).

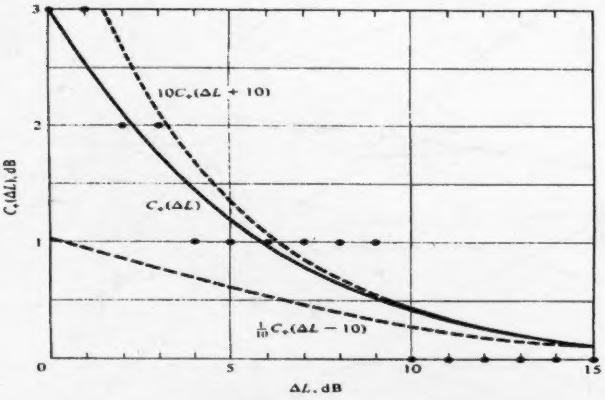
So, $C_+ (\Delta L)$ is always considered for the positive values of ΔL. "For applications requiring only integer decibel accuracy, a convenient approximation is (Bell, 1982):"

$\Delta L = 0, 1$	$C_+ (\Delta L) = 3$
$\Delta L = 2, 3$	$C_+ (\Delta L) = 2$
$\Delta L = 4, 5, 6, 7, 8, 9$	$C_+ (\Delta L) = 1$
$\Delta L = 10$ *or greater*	$C_+ (\Delta L) = 0$



Relative response functions for A, B, and C weightings.

Figure 5-1



Decibel addition function $C_+(\Delta L)$; solid line gives function for ΔL between 0 and 16 dB; dashed lines give $10C_+(\Delta L + 10)$ and $\frac{1}{10}C_+(\Delta L - 10)$, both of which approach $C_+(\Delta L)$ in limit of large ΔL. Dots are the integer-decibel approximation to $C_+(\Delta L)$.

Figure 5-2

Based on the center frequencies, the audible Octave band measurement could only measure bands as :

16, 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, 16000, and 31500 Hz

As an example, in order to find out the estimated *A-weighted* sound level of an Octave band sound-pressure measurement, it may be said that:

Since the individual band components partitioned in the sound is not known, each band may be corrected for the *A-weighting* of it by using the correction amount at its center frequency (Pierce, 1981).

Center frequency in Hz	Correction for *A-weighting* in dB
31.5	-39
63	-26
125	-16
250	-9
500	-3
1000	0
2000	+1
4000	+1
8000	-1
16000	-7

In the following, solution to a couple of numerical examples is provided, because the method will be used intensively for the calculation of the slurry pipeline in this thesis later on.

Example:

Assume that the Octave-band sound pressure levels measured at a point in a factory are as tabulated below:

dB	Cent. Freq.
76	31.5
80	63
85	125
87	250
90	500
92	1000
96	2000
94	4000
94	8000
86	16000

Find out the ***A-weighted*** sound level in the tested area.

Solution:

The level for ***A-weighting*** needed to be corrected by using the correction that is related to the band center frequency. As the result (see Fig. 5-1) it may be written as:

$$\underbrace{76-39,\ 80-26},\ \underbrace{85-16,\ 87-9},\ \underbrace{90-3,\ 92-0},\ \underbrace{96+1,\ 94+1},\ \underbrace{94-1,\ 86-7}$$

The composite estimate then will be:

$$L_A = (37 \oplus 54) \oplus (69 \oplus 78) \oplus (87 \oplus 92) \oplus (97 \oplus 95) \oplus (93 \oplus 87)$$

$$L_A \cong [54 + C_+(17)] \oplus [78 + C_+(9)] \oplus [92 + C_+(5)] \oplus [97 + C_+(2)] \oplus [93 + C_+(6)]$$

$$L_A \cong [54 + 0] \oplus [78 + 1] \oplus [92 + 1] \oplus [97 + 2] \oplus [93 + 1]$$

$$L_A \cong [54 \oplus 79] \oplus [93 \oplus 99] \oplus 94$$

$L_A \cong [79 + C_+ (25)] \oplus [99 + C_+ (6)] \oplus 94$

$L_A \cong [79 + 0] \oplus [99 + 1] \oplus 94$

$L_A \cong [79 \oplus 100] \oplus 94$

$L_A \cong [100 + C_+ (21)] \oplus 94$

$L_A \cong [100 + 0] \oplus 94$

$L_A \cong [100 \oplus 94] \cong [100 + C_+ (6)] \cong [100 + 1] \cong 101 \text{ dB}$

Example:
Now for the same problem if the question was to find the total sound level with no weighting effect (linear reading), then:

$Total\ L = 10 \log [\Sigma 10^{Ln/10}]$

$Total\ L = 10 \log [10^{L1/10} + 10^{L2/10} + 10^{L3/10} + \ldots + 10^{Ln/10}]$

$L_1 = 76, L_2 = 80, L_3 = 85, L_4 = 87, L_5 = 90, L_6 = 92, L_7 = 96, L_8 = 94, L_9 = 94, L_{10} = 86$

$Total\ L = 10 \log [10^{7.6} + 10^{8} + 10^{8.5} + 10^{8.7} + 10^{9} + 10^{9.2} + 10^{9.6} + 10^{9.4} + 10^{9.4} + 10^{8.6}]$

$L_T = 10 \log [1.295^{10}]$

$L_T = 101.12 \text{ dB} \cong 101 \text{ dB} \cong L_A$

Example:
The ambient background sound level in a lab measured (linear reading) at the specific frequency of 2000 Hz, and found to be 64 dB. Now if the circulating pump at the pipe loop is started up and the sound level measurement next to the loop at the same frequency (2000 Hz) is found to be 76 dB, what would the net sound level of the flow in the loop next to the pipe be?

Solution:

$Total\ L = 10 \log [\Sigma 10^{Ln/10}]$

$76 = 10 \log [10^{64/10} + 10^{L2/10}]$

$\log [10^{64/10} + 10^{L2/10}] = 7.6$

$$10^{L2/10} = \mathit{antilog}\ 7.6 - 10^{6.4}$$

It is known by logarithm definition that if:

$\log_p q = r$ then: $p^r = q$

As the result:

$$L_2 = 10 \log [\mathit{antilog}\ 7.6 - 10^{6.4}]$$

$$L_2 = 75.7\ dB$$

5.2.2: SOUND POWER LEVEL MEASUREMENT

Again, due to the vast numerical ranges involved in measuring the sound powers, the logarithmic scale is in use, which condenses the range and simplifies the computation (Dowling, 1983). "By definition, sound power is the rate at which acoustical energy is radiated from a sound source, and its unit is watt (Bell, 1982)." The power level *(PWL)* of sound is also in decibels *(dB)* and given by:

$$PWL = 10\log_{10}\left(\frac{soundpoweroutput}{10^{-12}\,watts}\right) = 10\log_{10}\left(\frac{W}{W_{ref}}\right) \qquad \text{(E5-3)}$$

$$PWL = 10 \log_{10}(\mathit{sound\ power\ in\ watts}) + 120dB$$

On this scale, the pain threshold (*Power level* = $1\ Watt/m^2$) is in correspondence with an intensity level of (Serway, 1982):

$$PWL = 10 \log_{10} (1/10^{-12}) = 10 \log (10^{12}) = 120\ dB$$

As an example:

PWL for a human shout is 70 dB, 1 dB is equivalent to $10^{-11.9}$ W/m^2, and 50 dB is equivalent to 10^{-7} W/m^2 dB. The two have a non-linear relation (logarithmic relation)

5.2.3: BARRIER MATERIALS ON THE SOUND PATH

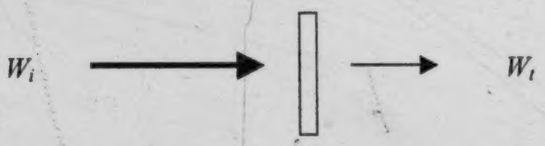
The sound isolating capability of a wall is called the *transmission coefficient (τ)* of that material (Bell, 1982).

$$\tau = W_t/W_i \qquad \text{(E5-4)}$$

Where:

W_t = sound power transmitted (watt)

W_i = sound power incident (watt)



Let's consider the relationship between the sound power, its intensity, and its pressure. It may be shown (Bell, 1982) that for a homogeneous wall and plane sound waves the transmission coefficient is (unit less):

$$\tau(\theta) = \frac{I_t}{I_i} = \frac{|p_t^2|}{|p_i^2|} = \{[1 + \eta(\frac{\omega\rho_s}{2\rho c}\cos\theta)(\frac{\omega^2 B}{c^4\rho_s}\sin^4\theta)]^2 + [(\frac{\omega\rho_s}{2\rho c}\cos\theta)(1 - \frac{\omega^2 B}{c^4\rho_s}\sin^4\theta)]^2\}^{-1}$$

Where in the above equation (E5-5):

I_t : Sound intensity transmitted (W/m^2)

I_i : Sound intensity incident (W/m^2)

P_t : Sound pressure transmitted (P_a)

P_i : Sound pressure incident (P_a)

θ : Angle of incident (radian)

η : Composite plate loss factor (unit less)

ρ_s : Plate surface density (kg/m^2)

B : Plate bending stiffness per unit width (N/m)

ρ : Density of medium (kg/m^3)

c : Speed of sound in medium (m/s)

The equation above is not very useful, because it depends on the incident angle. In order to convert that into a more consistent and practical form, a logarithmic term called the transmission loss (*TL*) was defined as:

$$TL = 10 \log 1/\tau \qquad [\text{dB}] \qquad \text{(E5-6)}$$

Where "τ" is the transmission coefficient averaged over all angles of incidence.

By substituting equation (E5-6) in (E5-5) and assuming that the term:

$$\omega^2 B/c^4 \rho << 1$$

The transmission loss may be approximated over a wide range of usefulness as:

$$TL \approx 10 \log\left[1 + \left(\frac{\omega \rho_s}{2\rho c}\cos\theta\right)^2\right] \qquad [\text{dB}] \qquad \text{(E5-7)}$$

Equation (E5-7) is called the *limp-wall law transmission loss,* as its only characteristic involved is the surface mass of the wall. Note that for $\theta = 0°$ (sound impinging at normal incidence to the wall), *TL* is the largest and for $\theta = 90°$ (at grazing incidence), *TL* reduces to zero.

In practice, the sound wave is incident over a wide range of angles. The averaging of equation (B5-7) ends up as (Bell, 1982):

$$TL = 20 \log (f) + 20 \log (W) - C \qquad [\text{dB}] \qquad \text{(E5-8)}$$

Where:

f: Frequency (Hz)

W: Surface density (kg/m^2/cm, thickness or lb/ft^2/in, thickness)

For steel pipe: 78.4 in metric and 18.5 in imperial system

For clear PVC pipe: 14 in metric and 3.3 in imperial system

Density of the clear PVC is 1400 kg/m^3 (Johnson)

C: Coefficient 47 if W is in (kg/m^2/cm)

C: Coefficient 33 if W is in (lb/ft^2/in)

Example:

What would be the transmission loss of a sound within a clear PVC pipe at 125 Hz and 82 dB incidences, when measured next to the pipe wall outside? The thickness of the pipe wall is 3.68 mm.

Solution:

$t = 0.368\ cm \qquad W = 14 * 0.368 = 5.15\ kg/m^2/cm\ thickness$

$TL = 20 \log (f) + 20 \log (W) - C$

$TL = 20 \log (125) + 20 \log (5.15) - 47$

$TL = 9.2\ dB$

So, the expected sound level measured next to the PVC pipe would be:

$82 - 9.2 = 72.8\ dB$

Some steel pipe specification tables (7-1, 7-2) are made available at the beginning of Chapter 7: Appendix, page 103. The data is at its original form (imperial units).

5.2.4: RESONANCE ACROSS A PIPE

At the first resonance mode (also called fundamental mode), the wavelength is twice the length of the pipe diameter (Serway, 1982).

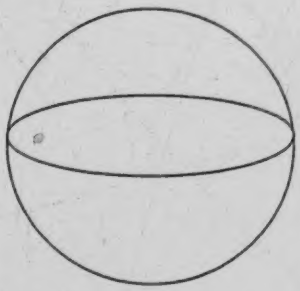


Figure 5-3: First resonance mode across a pipe's diameter

That means, twice the diameter travel is equal to the wavelength.

$\lambda_1 = 2D$

$f_1 = C / \lambda_1 = C / 2D$

At the second resonance mode, the wavelength is equal to the diameter travel of the pipe. That means, twice the diameter is equal to twice the wavelength.

$2\lambda_2 = 2D$ $\qquad\qquad$ $\lambda_2 = D$

$f_2 = C / \lambda_2 = C / D$

$f_2 = 2f_1$

At the third resonance mode, the wavelength is equal to the 2/3-diameter travel of the pipe. That means, twice the diameter is equal to three times the wavelength.

$3\lambda_3 = 2D$ $\qquad\qquad$ $\lambda_3 = 2/3\ D$

$f_3 = C / \lambda_3 = 3C / 2D$

$f_3 = 3f_1$

5.3: METHODOLOGY AND RESEARCH OBJECTIVES

Moving slurry within the pipeline generates a natural audible noise spectrum. If the spectrum was measured, recorded, figure illustrated, and investigated, some resonance frequencies of the flow noise may be identified and could be linked to the amount of air content in the slurry.

5.4: APPROACH

A decision was made to do a pilot test and measurement in the lab first. The results were to help set up the measurement method and tool in order to do the same at the slurry pipelines in the Syncrude mine sites.
The available sound level measurement was an ambient Sound Level Meter (SLM). Having the PVC test loop pump shut, the ambient sound level spectrum at the test table in the pilot plant was measured. The next task was to measure the sound level with the tip of the meter touching the PVC loop, once its pump was running. The measured sound level spectrum was the combined sum of pipe noise plus the ambient noise. When the ambient noise was taken out mathematically, the result was to be the pipe noise level spectrum that existed next to the outside pipe. Finally, in order to determine what the noise level was in the pipe, the sound level transmission loss that occurred through the wall of the PVC pipe was added up. The measurement data and its related calculation and figures are skipped here to avoid repetition. The same method was used at the mine sites.

At the mine sites, similar sound level measurements were conducted. In order to show the possible difference in the pipe readings, the separate measurement at the bottom, the side, and the top of the pipelines were made. To account for the sound level transmission loss, the pipe wall material (standard steel) and thickness were considered for the purposes of calculation.

5.5: NOISE LEVEL MEASUREMENT OF THE SLURRY PIPELINES AT SYNCRUDE MINE SITES

5.5.1: PIPE MEASUREMENT POSITIONS

At North Mine site, eight sets of measurement were made and recorded for each of the following positions: The side (3 o'clock position) and top (12 o' clock position) of the 27" pipeline. It was not practical to conduct the measurement at the bottom (6 o' clock position) of the pipeline because there wasn't a right location found to do so. At the Aurora Mine, five sets of measurement were done and recorded for the bottom, the side, and the top of the 30" pipeline.

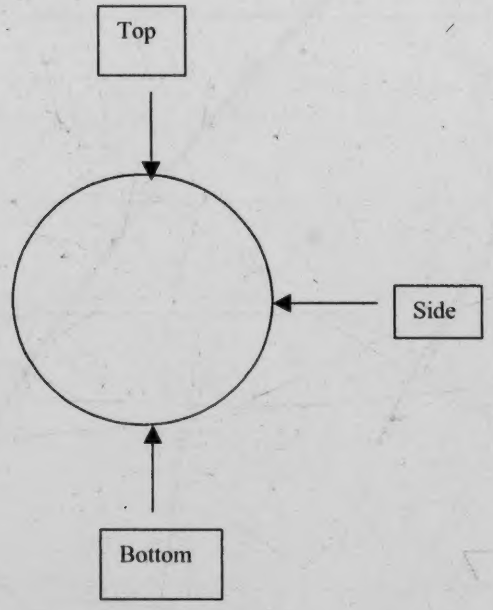


Figure 5-4: Measurement points on the pipeline

5.5.2: MEASUREMENTS AT NORTH MINE

The main pumping station was located down the north mine pit. There were two slurry pipelines each made from standard 27" diameters standard steel pipe. They ran parallel to each other at about 30 cm apart, with overall length of 4.8 Km. Each line was equipped with two Warman centrifugal pump in series of 2500 HP each, at the start point (pumping station). At a point 1.2 Km down the line, a booster pump station is located. Again, two centrifugal pumps of 2500 HP each in series boost up the flow in each line. According to the control room operator, the normal operating pressure of each pipeline may vary between 770 to 900 kPa (max. 1300 kPa), the density of the tar sand slurry may be somewhere between 1.46 to 1.49 (max. 1.6), and its temperature between 56 to 70 degree centigrade. The normal pumping capacity was about 4400 to 4700 tons/hr (max. 6650 tons/hr).

On the days that the measurement (April 24 & 25th., 2001) took place a spot was picked about 150 meters downstream from the booster pump station, which was located slightly up the hill. The spot was also about 30 meters away from a hauling road, and five meters blow it. The weather was partly cloudy but very windy, gusting up to 60 Km/hr. On the first couple of ambient sound level measurements, it was noticed that the wind effect was causing a higher decibel reading. In order to correct that to some extent, a large cardboard box was backed up to a dirt pile and to the wind, was used to block the direct blast of the wind. The meter then was held in the large opening of the box for the ambient noise measurement. The other factor that had some effect on the measurement was the fact that two pipelines ran parallel to each other and were separated only by 30 cm apart. For the top measurement, the instrument could have picked up some combined noise from both pipeline simultaneously.

A set of eight sound level measurements of the ambient noise, the pipeline side, and the pipeline top were taken. The instrument setting for all sound level measurement was as follows:

- Range: From 12.5 Hz to 20 kHz
- Time mode: 1/3 Octave band filter set
- Response: Slow
- Weighting: Linear
- Mode: SPL (Sound Pressure Level)
- dB Range (sensitivity): 60 to 120 dB

On auto run mode, the SLM instrument scans for about 10 seconds on each range frequency. At the end of each run, the saved data may be downloaded in the Hyperterminal program in a laptop. Later on, the data can be imported into the Excel spreadsheet and processed.

There was no suitable spot found at the site, to place the sound level meter beneath the pipeline, in order to take the bottom readings. The individual readings and its related figure may be found in the Appendix. In the following, only the figure presenting the average of each group is presented.

Average Ambient Sound Level Spectrum, North Mine

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	78.0	83.4	69.9	88.1
16	76.0	80.9	69.7	86.1
20	77.9	84.0	69.2	87.9
25	72.5	77.7	65.7	82.6
31.5	77.5	83.9	67.4	87.3
40	72.1	77.3	66.2	82.3
50	67.2	71.6	62.0	77.3
63	67.4	72.4	61.1	77.4
80	70.0	74.7	64.5	80.1
100	65.8	69.5	62.9	75.8
125	66.3	68.9	63.3	76.3
160	66.0	69.6	62.4	76.1
200	61.1	63.8	58.9	71.2
250	58.2	60.7	56.1	68.3
315	55.7	58.8	53.2	65.7
400	54.8	57.6	52.2	64.8
500	52.5	56.2	49.1	62.5
630	48.8	51.8	46.3	58.9
800	50.3	54.0	47.2	60.4
1000	48.5	51.1	46.4	58.5
1250	48.6	51.9	46.1	58.7
1600	47.7	50.1	45.1	57.7
2000	46.1	49.4	43.3	56.2
2500	43.7	46.5	40.8	53.8
3150	45.7	48.2	43.4	55.8
4000	46.2	48.0	44.3	56.2
5000	45.4	47.4	43.8	55.5
6300	43.8	46.0	42.4	53.9
8000	49.7	51.0	47.8	59.8
10000	50.2	52.2	48.9	60.3
12500	43.5	48.3	39.8	53.5
16000	44.5	47.9	42.0	54.5
20000	40.3	45.0	36.2	50.4
Overall	**84.6**	**90.2**	**77.4**	**94.7**

Table 5-1

The overall value indicates the Sound Level intensity (dB) of the average spectrum figure as a single combined sound. As an example the SEL = 94.7 dB for this experiment.

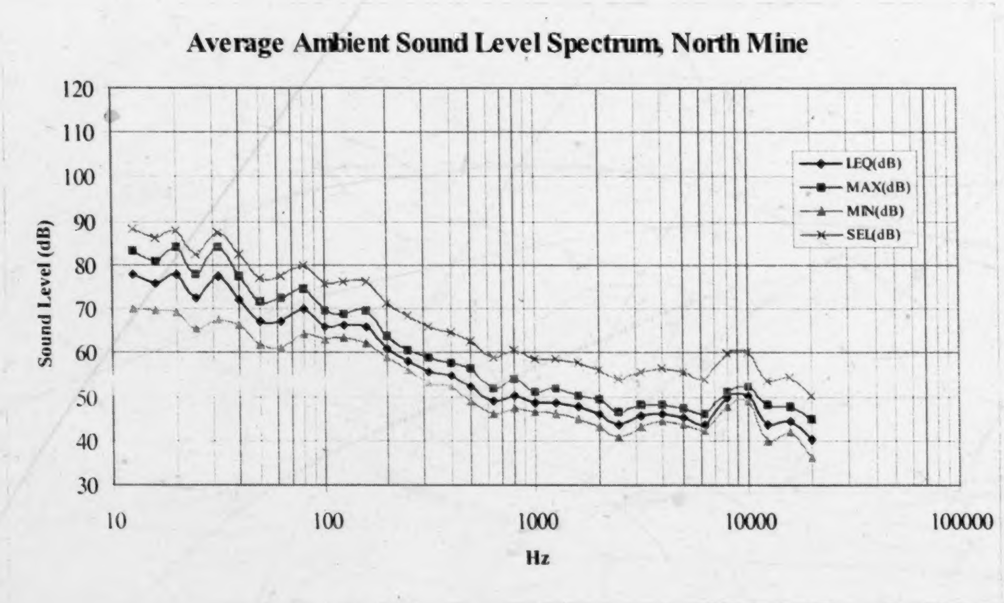

Average Ambient Sound Level Spectrum, North Mine
120
110
100
90
80
70
60
50
40
30
Sound Level (dB)
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Figure 5-5

Average Net Inside Pipeline Sound Level Spectrum
side of slurry flow, North Mine

Average				
FREQ(Hz)	**LEQ(dB)**	**MAX(dB)**	**MIN(dB)**	**SEL(dB)**
12.5	103.6	108.1	97.2	113.7
16	103.9	109.1	96.6	114.0
20	107.5	112.4	100.4	117.6
25	107.8	113.0	100.5	117.8
31.5	107.1	112.5	100.0	117.2
40	110.8	116.3	103.1	120.9
50	111.0	115.8	102.4	121.1
63	109.9	115.2	103.3	119.9
80	110.4	115.5	103.0	120.5
100	110.8	116.3	103.2	120.9
125	111.3	116.7	103.5	121.4
160	112.1	116.6	103.8	122.2
200	111.1	115.7	104.9	121.5
250	113.3	118.7	105.6	123.3
315	113.3	118.6	105.3	123.3
400	110.2	115.8	103.6	120.3
500	113.5	118.4	107.3	123.6
630	115.5	120.2	109.2	125.5
800	113.8	118.9	107.4	123.9
1000	115.4	119.4	110.3	125.5
1250	114.5	118.1	111.3	124.6
1600	118.2	120.8	116.1	128.3
2000	119.1	121.2	117.4	129.1
2500	118.5	121.0	116.4	128.6
3150	118.6	120.7	116.7	128.6
4000	118.8	121.2	117.0	128.8
5000	120.7	122.8	118.7	130.8
6300	123.5	125.7	121.4	133.6
8000	125.1	126.7	123.8	135.2
10000	124.5	125.8	123.4	134.5
12500	128.1	129.7	126.8	138.2
16000	129.4	131.0	128.3	139.5
20000	124.8	127.9	122.5	134.7
Overall	**135.4**	**137.7**	**133.7**	**145.5**

Table 5-2

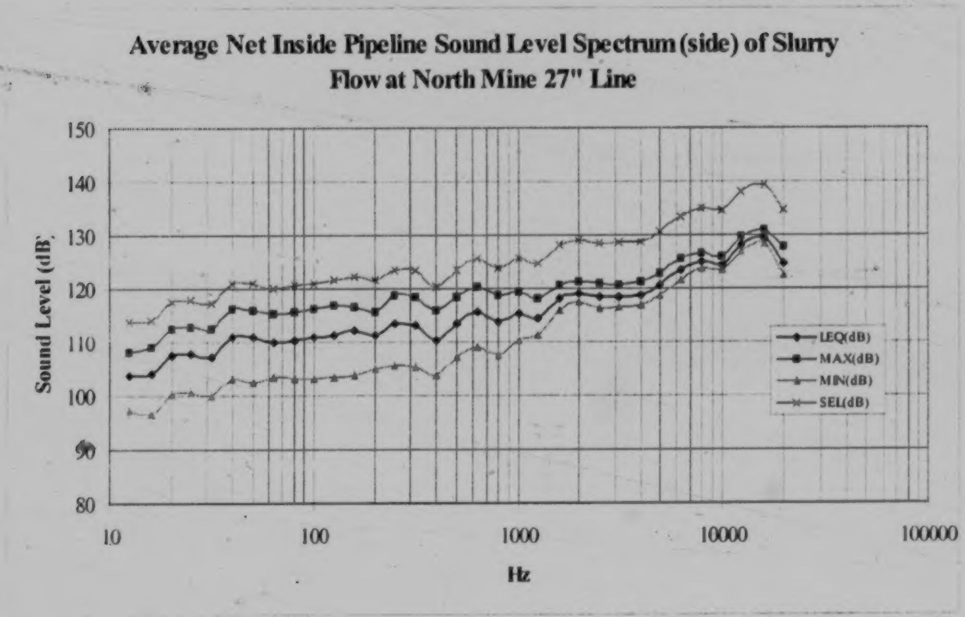

Average Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line
Sound Level (dB)
150
140
130
120
110
100
90
80
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Figure 5-

Average Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow
North Mine

Average FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	107.2	112.3	100.2	117.3
16	106.6	111.0	101.6	116.7
20	108.2	113.3	99.8	118.3
25	110.7	115.9	103.1	120.8
31.5	109.8	114.4	103.9	120.0
40	112.4	117.7	104.7	122.5
50	115.2	120.4	109.7	125.3
63	113.7	119.3	107.3	123.7
80	116.6	121.3	109.9	126.7
100	113.4	117.9	106.2	123.4
125	112.2	118.5	104.7	122.3
160	112.6	118.8	104.2	122.7
200	111.5	116.8	104.4	121.6
250	111.5	116.6	102.4	121.6
315	110.4	115.4	104.0	120.5
400	112.7	118.3	104.2	122.8
500	113.0	119.0	106.1	122.6
630	113.5	118.8	107.3	123.6
800	115.2	120.4	109.6	125.2
1000	115.9	121.1	109.9	126.0
1250	114.0	117.7	110.1	124.1
1600	117.1	121.9	111.8	127.2
2000	117.6	121.6	114.1	127.7
2500	117.2	121.2	114.0	127.3
3150	115.9	119.0	113.8	125.9
4000	117.5	120.9	114.8	127.6
5000	118.5	121.4	116.1	128.6
6300	120.7	123.4	118.2	130.8
8000	121.4	123.3	120.6	131.4
10000	122.8	124.6	121.4	132.9
12500	125.6	127.4	124.4	135.7
16000	129.9	133.0	126.7	140.0
20000	121.5	125.7	120.4	132.0
Overall	134.3	137.6	131.5	144.4

Table 5-3

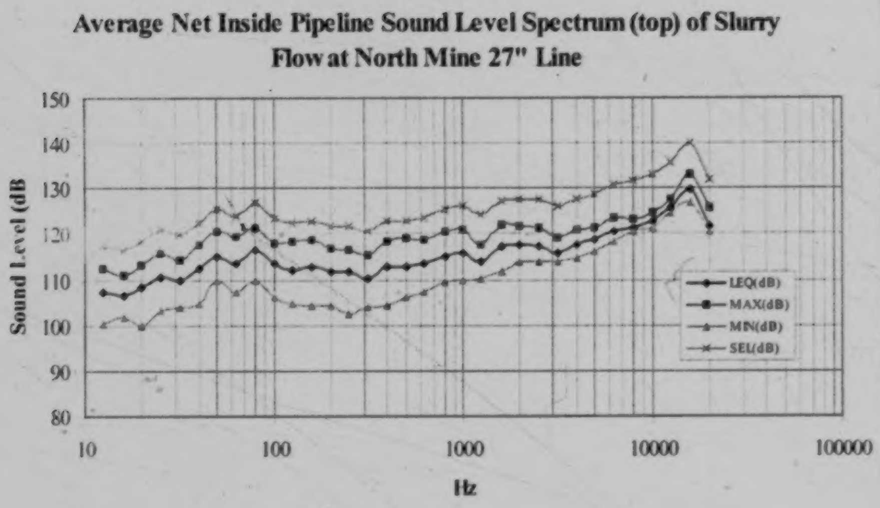

Average Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line
Sound Level (dB
150
140
130
120
110
100
90
80
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Figure 5-

5.5.3: MEASUREMENTS AT AURORA MINE

Both the main pumping station and the booster station are located on flat land and are about 1.2 km apart. The single slurry pipeline (train) in operation was constructed from the standard 30" diameter steel pipe. Each station has two centrifugal pumps in series, 2500 HP each. According to its operator, the operating pressure of the pipeline was at7300 kPa, with the average density of the slurry at about 1.5, and its temperature at 30 degree centigrade.

On the day the measurement took place (April 26, 2001), a spot was picked about 100 meters downstream from the booster pump station, on a flat run next to an expansion joint. The local weather was sunny and calm. A set of five sound level measurements were taken from the ambient, the bottom, the side, and the top of the pipeline. The individual readings and its figure may be found in the Appendix. In the following, only the figure presenting the average of each group is presented.

Average Ambient Sound Level Spectrum
Aurora Mine

Average FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	58.3	61.7	53.5	68.4
16	53.2	58.0	48.5	63.2
20	53.4	57.2	49.5	63.5
25	57.9	61.7	53.9	68.0
31.5	57.3	60.2	54.8	67.4
40	58.4	61.8	55.1	68.5
50	59.1	61.4	56.6	69.1
63	60.3	62.7	57.8	70.4
80	60.7	63.5	57.4	70.7
100	59.8	62.0	58.0	69.8
125	58.9	60.6	57.1	69.0
160	56.2	57.9	54.4	66.3
200	53.3	55.4	52.1	63.4
250	46.6	48.6	45.2	56.7
315	46.9	50.0	43.7	57.0
400	44.6	46.4	43.6	54.7
500	43.8	45.6	42.2	53.8
630	42.8	45.9	40.8	52.9
800	42.3	44.1	41.0	52.4
1000	40.2	42.0	39.0	50.3
1250	39.3	41.2	37.8	49.4
1600	39.0	41.4	37.2	49.1
2000	37.1	39.0	35.6	47.2
2500	35.0	37.5	33.2	45.0
3150	43.7	45.1	41.0	53.8
4000	45.1	46.1	43.1	55.2
5000	43.9	45.0	43.3	54.0
6300	42.6	43.7	41.7	52.7
8000	49.5	50.5	47.6	59.6
10000	49.6	50.8	48.6	59.7
12500	39.7	44.7	38.0	49.8
16000	42.9	44.2	41.0	52.9
20000	36.3	39.5	34.5	46.4
Overall	**69.5**	**72.2**	**66.8**	**79.6**

Table 5-4

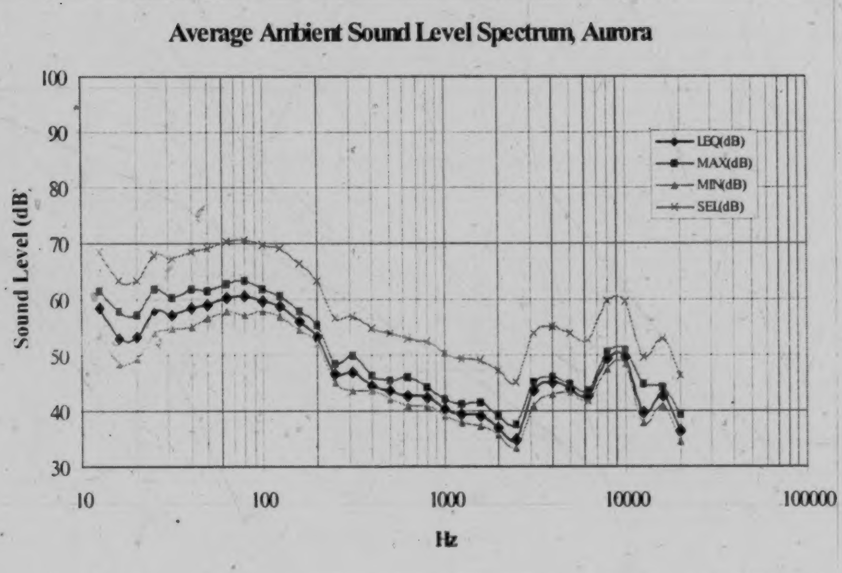

Average Ambient Sound Level Spectrum, Aurora
Sound Level (dB)
100
90
80
70
60
50
40
30
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Figure 5-

Average Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow
Aurora Mine

Average FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	82.7	87.4	76.0	91.1
16	86.7	92.5	77.3	96.8
20	85.9	91.0	78.1	96.0
25	91.3	94.3	87.0	101.4
31.5	85.3	90.7	80.2	95.3
40	83.1	88.2	76.8	93.3
50	85.5	91.4	79.8	95.6
63	87.4	91.3	82.8	96.0
80	88.2	91.6	84.1	98.4
100	85.8	91.6	81.3	96.0
125	90.8	97.1	84.4	100.8
160	85.6	93.6	80.5	96.2
200	87.1	93.1	82.1	97.7
250	87.3	91.7	83.0	97.3
315	95.2	99.2	89.9	105.2
400	94.6	99.2	91.3	104.6
500	96.2	99.5	93.5	106.2
630	100.3	103.1	97.7	110.4
800	103.3	106.7	99.1	113.3
1000	105.4	109.0	102.4	115.5
1250	107.9	110.8	105.3	118.0
1600	113.7	117.4	111.2	123.7
2000	113.0	115.3	111.0	123.0
2500	112.4	114.9	111.0	122.4
3150	114.1	117.3	111.4	124.0
4000	115.9	119.1	112.9	125.9
5000	113.1	115.7	111.3	123.2
6300	115.0	117.7	112.6	125.0
8000	116.9	119.6	116.1	127.0
10000	119.4	121.5	117.3	129.4
12500	124.3	128.7	121.4	134.4
16000	126.1	129.8	123.2	136.1
20000	121.5	125.5	119.2	131.7
Overall	**130.6**	**134.2**	**128.0**	**140.7**

Table 5-5

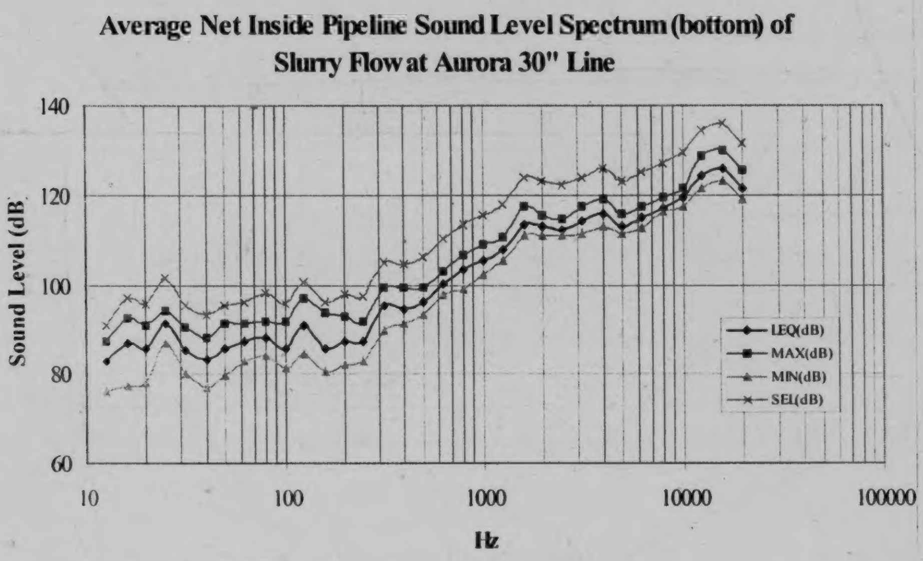
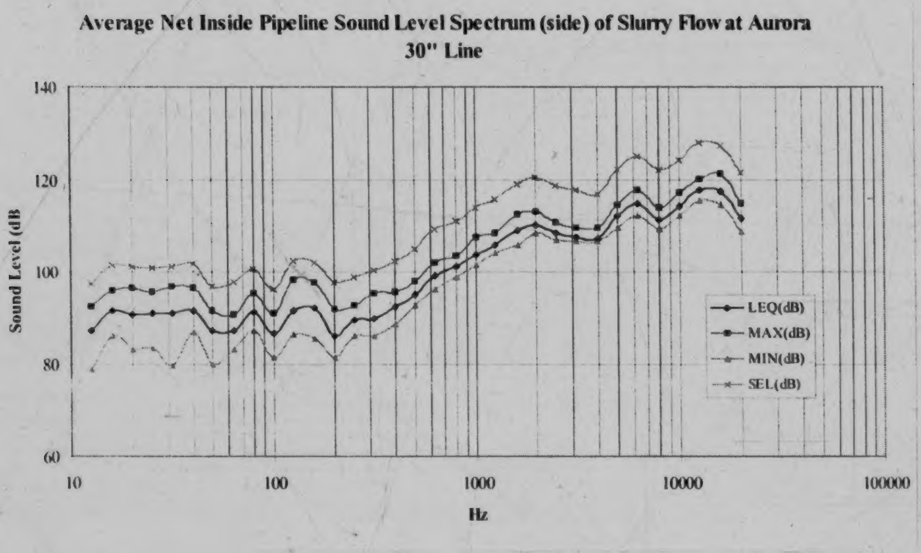

Average Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line
140
120
100
80
60
Sound Level (dB
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Figure 5-9

Average Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow
Aurora Mine

Average FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	87.3	92.5	78.6	97.4
16	91.5	95.8	85.9	101.6
20	90.7	96.6	83.1	101.1
25	90.8	95.7	83.2	100.9
31.5	91.0	96.6	79.6	101.1
40	91.6	96.5	86.9	101.6
50	87.0	91.5	79.9	96.9
63	87.1	90.8	82.9	97.5
80	91.3	95.2	87.2	100.7
100	86.4	91.1	81.4	96.2
125	91.6	98.2	86.3	102.4
160	92.0	97.8	85.5	102.1
200	86.0	91.9	81.3	97.7
250	89.4	92.8	86.0	98.8
315	89.8	95.4	86.1	100.2
400	92.4	95.6	88.5	102.2
500	95.1	98.1	92.8	105.1
630	99.2	101.9	96.3	109.3
800	101.1	103.4	98.7	111.1
1000	103.9	107.5	101.5	114.0
1250	105.9	108.5	104.1	115.9
1600	109.0	112.5	106.0	119.1
2000	110.2	113.1	108.4	120.3
2500	108.5	110.7	107.0	118.5
3150	107.7	109.5	106.7	117.7
4000	107.4	109.7	106.6	117.0
5000	112.1	114.7	109.6	122.1
6300	114.9	118.0	112.2	125.0
8000	111.3	113.9	109.4	122.2
10000	114.3	117.2	112.2	124.2
12500	117.9	120.1	115.6	128.0
16000	117.6	121.3	114.5	127.5
20000	111.6	115.0	108.8	121.5
Overall	**124.3**	**127.2**	**121.9**	**134.3**

Table 5-6



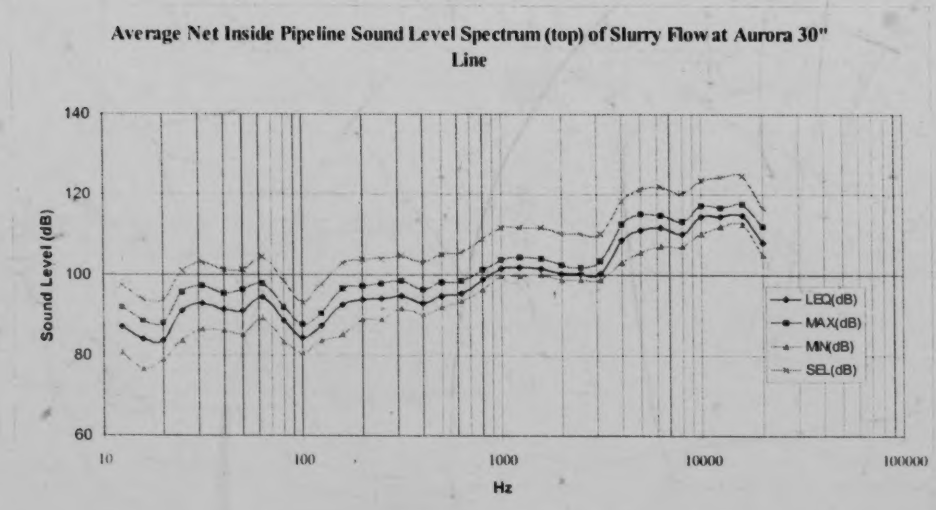
Average Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line

Figure 5-

Average Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow
Aurora Mine

Average FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	87.1	92.2	80.6	97.1
16	84.0	88.7	76.7	94.0
20	83.8	88.0	79.0	93.9
25	91.0	95.6	83.6	101.1
31.5	93.0	97.1	86.5	103.0
40	91.2	95.5	86.0	101.3
50	91.1	96.4	85.4	101.1
63	94.5	97.9	89.1	104.4
80	88.5	91.8	83.5	98.4
100	84.4	87.5	80.7	93.4
125	87.5	90.5	83.7	97.4
160	92.7	96.7	85.4	102.7
200	93.7	97.2	88.9	103.7
250	94.1	97.8	88.9	104.1
315	94.8	98.5	91.6	104.6
400	93.0	96.4	90.2	103.1
500	94.9	98.2	92.0	104.9
630	95.5	98.4	93.5	105.6
800	98.8	101.3	96.3	108.8
1000	101.6	103.7	99.7	111.7
1250	101.7	104.2	99.6	111.7
1600	101.6	103.9	99.9	111.6
2000	100.2	102.4	98.6	110.3
2500	100.2	102.0	98.8	110.2
3150	100.4	103.4	98.8	110.3
4000	108.5	112.8	103.1	118.5
5000	111.2	115.2	105.6	121.2
6300	111.7	114.8	107.2	121.8
8000	110.1	113.3	107.1	120.3
10000	114.4	117.2	110.1	123.5
12500	114.4	116.5	112.0	124.4
16000	114.8	117.5	112.5	124.5
20000	107.9	112.1	105.1	116.7
Overall	**121.7**	**124.7**	**118.4**	**131.5**

Table 5-7



Average Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line

Figure 5-

Several times the external noise level spectrum of the slurry pipelines at North Mine and Aurora Mine in Forth McMurray were measured, and presented above. Based on those results, the internal noise of each pipe was calculated. By analyzing the internal noise spectrum. which is the slurry's flow signature, it would be possible to estimate its air content.

5.6: PIPELINE MEASUREMENT METHODOLOGIES AND APPROACH

As mentioned in section "B" above, in addition to the ambient noise measurements, the SLM instrument at North Mine and Aurora Mine sites also recorded the noise level spectrum of the tar sand hydrotransport pipelines. Plotting and searching the spectrums may reveal the resonance frequencies of the slurry pipeline that could be related to the air (gas) content of the slurry.

5.7: MEASUREMENT CONDITION

At North Mine, eight-noise measurement sets for each position of the side (3 o'clock) and top (12 o' clock) positions of the 27" pipeline were taken. It was not practical to conduct measurement for the bottom (6 o' clock position) of the pipeline because there was no right location to do so. At the Aurora Mine, a set of five noise measurements were taken from the bottom, the side, and the top positions of the 30" pipeline.

5.8: SEARCHING THE MEASUREMENT RESULTS FOR RESONANCE

From this point on, for an example, samples from the measurement of side position at the 27" pipeline at North Mine will be analyzed, and discussed. The model can be applied to the sets of measurements with results provided in the Appendix.

5.8.1: THEORETICAL RESONANCE and SPEED of SOUND ACROSS THE 27" PIPELINE

The specifics of the 27" standard steel pipe is given as:

Diameter = 0.6588 meter
Wall thickness = 0.009525 meter

In average, the main components of the slurry by volume were taken as:

Bitumen: 9%
Sand (quartz): 36%

The subtotal counts for 45% and the rest (55%) would be mostly water, with a few percentages of air or gas in it. Note that sand content sizes up to only a few microns with the probability of 90%. Most of the larger sand particles crush against each other during the hydrotransportation and break down to smaller pieces continuously.

For physical properties of the materials, the data given at table 4-2 may be used. Speed of sound in the pipeline may be calculated by using the Shook's equation (E4-2).

$$1/C^2 = (\rho_a\alpha_a + \rho_q\alpha_q + \rho_b\alpha_b + \rho_w\alpha_w)[\alpha_a / B_a + \alpha_q / B_q + \alpha_b / B_b + \alpha_w / B_w + D / E_s t]$$

ρ: Density, Kg/m^3
α: Volumetric proportion

D: Pipe outer diameter, m

t: Wall thickness, m

B: Bulk modulus of material, Pa

E_s: Elastic modules of pipe, Pa

The subscript letters refers to:

a: Air

q: Quartz (sand)

b: Bitumen

w: Water

The expected air content by volume was less than 5% per Dr. Julian Coward's previous experiments. So the spreadsheet may be arranged for up to 5% of the air content. The results may be graphed as in the following figure:

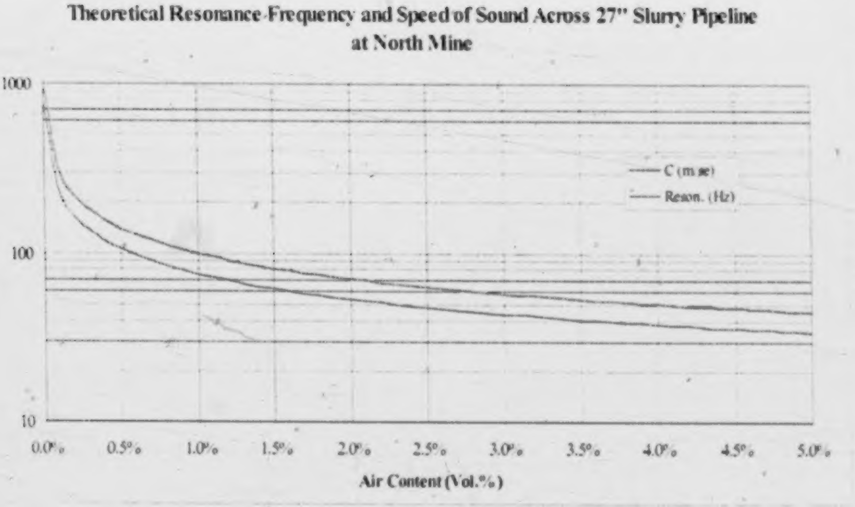

Theoretical Resonance Frequency and Speed of Sound Across 27" Slurry Pipeline at North Mine
1000
100
10
C (m/sec)
Reson. (Hz)
0.0%
0.5%
1.0%
1.5%
2.0%
2.5%
3.0%
3.5%
4.0%
4.5%
5.0%
Air Content (Vol.%)

Figure 5-

In the figures for measurement experiments, the sound level was plotted with respect to the frequency spectrum. Finding or assuming a resonance frequency leaded to calculate the related speed of sound for it. The total water and air content in one volume unit of slurry was to be 0.55, which means ($\alpha_a + \alpha_w = 0.55$). The unknown variables of Shook's equation were reduced to one unknown, which was air content volume (α_a), this may be solved easily. It was expected to have a low percentage of air (within 5% range) in the slurry. Then first resonance may be chosen in the range of 31.5 Hz (which corresponds to 5.99% air content) to 100 Hz (which corresponds to 0.56%) as a reasonable assumption. Knowing the first resonance range upper limit is to be 100 Hz, makes one certain that the upper limit for second and the third resonance range would be 200 and 300 Hz respectively.

In the following page, the first experimental figure for sound level measurement for the side position of 27" tar sand slurry pipeline at North Mine, is displayed as a sample. The bumps on the SEL curves may be checked and considered as possible resonance frequencies.

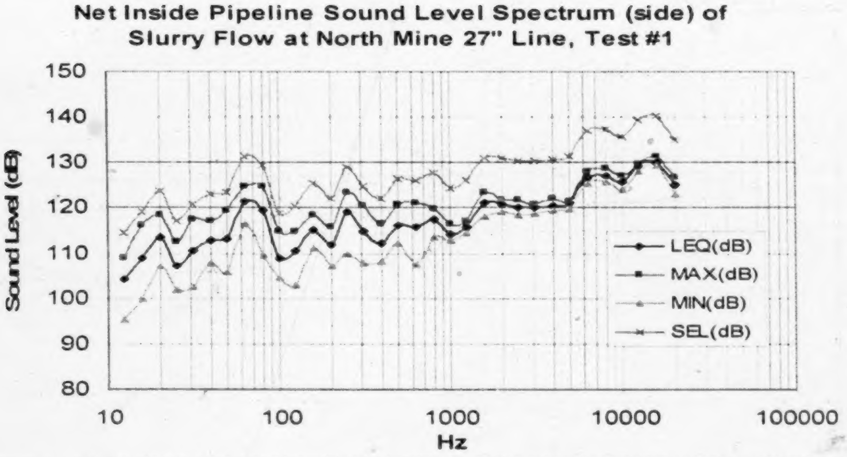

Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #1
150
140
130
120
110
100
90
80
Sound Level (dB)
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Figure 5.13

These readings then may be grouped into the first, second, and third resonance ranges that have been set up already. The results for the eight-spectrum measurement taken at North Mine would be displayed in the next page.

North Mine									
Side (SEL)		Max = 100		Max = 200		Max = 300			
Test #	more harmonics	f1	C1 = 2D/f1	f2 = 2f1	C2 = D/f2	f3 = 3f1	C3 = 2/3D/f3	C	dB
1		20	26.4					26.4	123.7
1		63	83.0					83.0	131.4
1		80	105.4					105.4	129.6
1				160	105.4			105.4	125.3
1						250	109.8	109.8	129.1
1	500								126.4
1	800								127.7
1	1600								131.1
1	6300								136.9
1	8000								137.4
1	12500								139.5
1	16000								140.2
2		16	21.1					21.1	119.9
2		50	65.9					65.9	127.9
2				160	105.4			105.4	136
2	630								138
2	1600								131.3
2	3000								134.4
2	5000								141.3
2	16000								139.5
[illegible]		25	32.9					32.9	126.8
[illegible]		40	52.7					52.7	125.3
[illegible]		80	105.4					105.4	123.3
[illegible]				160	105.4			105.4	120.8
[illegible]						250	109.8	109.8	124.7
[illegible]	1000								133.1
[illegible]	2000								132.1
[illegible]	8000								137.6
[illegible]	16000								142.2
4		12.5	16.5					16.5	120.6
4		31.5	41.5					41.5	124.6
4		50	65.9					65.9	121.7
4				125	82.4			82.4	126.2
4						250	109.8	109.8	125.1
4	630								133.2
4	1000								129.3
4	2000								131.1
4	8000								139.7
5		25	32.9					32.9	116.3
5		63	83.0					83.0	121.6
5				200	131.8			131.8	121.8
5	315								126.3
5	630								126.9
5	3150								132.5
5	6300								131.8
6		20	26.4					26.4	123.2
6		31.5	41.5					41.5	124.8
6		50	65.9					65.9	129.5
6		100	131.8					131.8	128.8
6				200	131.8			131.8	127.7
6	315								124.1
6	630								121.9
6	2000								130.1
6	8000								134.1
6	16000								139
[illegible]		25	32.9					32.9	115
		40	52.7					52.7	121.2
				125	82.4			82.4	124.8
						250	109.8	109.8	125
	1000								129.4
	2000								127.7
	8000								133.6
	16000								140.6
8		20	26.4					26.4	110.6
8		40	52.7					52.7	115.6
8				160	105.4			105.4	116.1
8						250	109.8	109.8	116.6
8	800								120.3
8	16000								138.3

Table 5-8: Resonance searching of 27" pipeline (side), North Mine

Through a calculation method similar to one used before, selected resonance frequencies in the table above will yield to the following air content values as tabulated below:

North Mine				
Side (SEL)			Valid	not valid
Test #	α_{a1}	α_{a2}	α_{a1}%	α_{a2}%
1	0.1604	1.2729	16.04	127.29
1	**0.0144**	1.4189	**1.44**	141.89
1	**0.0089**	1.4244	**0.89**	142.44
1	**0.0089**	1.4244	**0.89**	142.44
1	**0.0082**	1.4251	**0.82**	142.51
1				
1				
1				
1				
1				
1				
1				
2	0.2756	1.1577	27.56	115.77
2	**0.0231**	1.4102	**2.31**	141.02
2	**0.0089**	1.4244	**0.89**	142.44
2				
2				
2				
2				
2				
[redacted]	0.0978	1.3355	9.78	133.55
[redacted]	**0.0365**	1.3968	**3.65**	139.68
[redacted]	**0.0089**	1.4244	**0.89**	142.44
[redacted]	**0.0089**	1.4244	**0.89**	142.44
[redacted]	**0.0082**	1.4251	**0.82**	142.51
[redacted]				
[redacted]				
[redacted]				
[redacted]				
4				
4	**0.0599**	1.3734	**5.99**	137.34
4	**0.0231**	1.4102	**2.31**	141.02
4	**0.0147**	1.4187	**1.47**	141.87
4	**0.0082**	1.4251	**0.82**	142.51
4				
4				
4				
4				
5	0.0978	1.3355	9.78	133.55
5	**0.0144**	1.4189	**1.44**	141.89
5	**0.0056**	1.4277	**0.56**	142.77
5				
5				
5				
5				
6	0.1604	1.2729	16.04	127.29
6	**0.0599**	1.3734	**5.99**	137.34
6	**0.0231**	1.4102	**2.31**	141.02
6	**0.0056**	1.4277	**0.56**	142.77
6	**0.0056**	1.4277	**0.56**	142.77
6				
6				
6				
6				
6				
[redacted]	0.0978	1.3355	9.78	133.55
[redacted]	**0.0365**	1.3968	**3.65**	139.68
[redacted]	**0.0147**	1.4187	**1.47**	141.87
[redacted]	**0.0082**	1.4251	**0.82**	142.51
[redacted]				
[redacted]				
[redacted]				
[redacted]				
8	0.1604	1.2729	16.04	127.29
8	**0.0365**	1.3968	**3.65**	139.68
8	**0.0089**	1.4244	**0.89**	142.44
8	**0.0082**	1.4251	**0.82**	142.51
8				
8				

Table 5-9: Air content searching of 27" pipeline (side), North Mine

The different harmonics of resonance frequencies may be grouped to its equivalent first harmonic as follows:

C	α_{a1}	Hz	f_1	f_3	f_5	Repeated f	f	Test freq	ResoFreq	Repeated f
41.5	0.0599	31.5	2			2	31.5	31.5	**31.5**	**2**
52.7	0.0365	40	3			3	40.0	40	**40**	**3**
65.9	0.0231	50	3			[illegible]	[illegible]	50	**50**	**3**
83.0	0.0144	63	2			**2**	**63.0**	63	**63**	**4**
87.8	0.0128	125		2		**2**	**62.5**			
105.4	0.0089	80	2			**2**	**80.0**	80	**80**	**11**
105.4	0.0089	160		4		**4**	**80**			
109.8	0.0082	250			5	**5**	**83.3**			
131.8	0.0056	100	1			**1**	**100.0**	100	**100**	**3**
131.8	0.0056	200		2		**2**	**100**			

Table 5-10: Resonance grouping of 27" pipeline (side), North Mine

By plotting "Speed of sound" versus "Air Content (vol.%)" with a second Y-axis to show the "Repeated Resonance Frequencies" the following figure was produced:

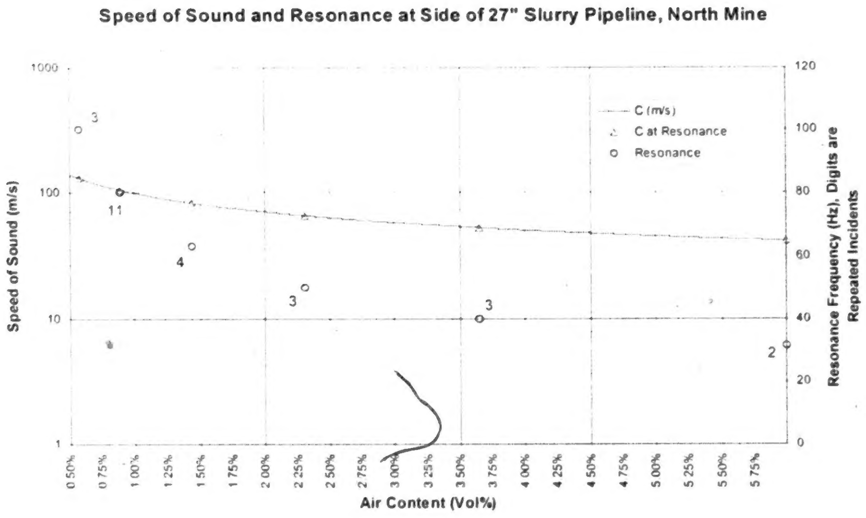

Speed of Sound and Resonance at Side of 27" Slurry Pipeline, North Mine
Speed of Sound (m/s)
1000
100
10
1
Resonance Frequency (Hz), Digits are Repeated Incidents
120
100
80
60
40
20
0
C (m/s)
C at Resonance
Resonance
3
11
4
3
3
2
0.50%
0.75%
1.00%
1.25%
1.50%
1.75%
2.00%
2.25%
2.50%
2.75%
3.00%
3.25%
3.50%
3.75%
4.00%
4.25%
4.50%
4.75%
5.00%
5.25%
5.50%
5.75%
Air Content (Vol%)

Figure 5-

5.9: CONCLUSION TO THE SECOND APPROACH

The above figure indicates that for test involving the side position of pipeline, most frequent resonance (11 times) occurred at frequency of 80Hz. This corresponds to 0.89% of air content in the slurry flow tested. The figure will not suggest that as a fixed number, because the mixture ratios and blends change continuously. Then, again the test results may vary at different locations along the pipeline. The above non-invasive method serves to present a scientific technique to estimate the air content in the slurry pipeline, based on listening to the audible sound level (noise) spectrum of its flow.

CHAPTER 6:

OVERALL CONCLUSION TO THE THESIS

The test methods presented in this thesis have demonstrated some scientific technique for estimating air content in the slurry. This technique can lead to the measurement of audible sound speed, and audible sound resonance within the pipeline. These methods could be used to develop an instrument to serve as a tool for instantaneous monitoring and on-line measurement of the slurry air content. The tools will assist the slurry pipeline handlers to measure and maintain the optimum air content of the tar sand slurry. This is needed to provide for good bitumen recovery, corrosion monitoring of the pipeline, as well as for achieving a more efficient pump performance in commercial oil sand hydrotranspot pipeline.

Specification of the Instruments Used

- Field FFT, Fast Fourier Transform Analyzer (scope & printer), ONO SOKKI, CF-200
- Tektronicx TDS 3012 (oscilloscope), DPO, 100 MHz, 1.25 GS/S
- Tiwatsu SS-5705 (oscilloscope), 40 kHz
- Amplifier: Optimus, 50 Watt, XL-50
- Omega Scientific E & L Instrument, 2001 Function Generator (square, saw blade, sine wave), range 0 to 100 kHz
- DC generator, Xantrex, Model HPD 30-10 SMSA
- Kistler series (211B5) Piezotron pressure transducers Quest Electronics Model 1800, Precision Impulse Integrating Sound Level Meter

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CHAPTER 7:

APPENDIX

7.1 : Steel Pipe Data

COMMERCIAL WROUGHT STEEL PIPE DATA (CRANE 1986)

s: standard
x: extra strong
xx: double extra strong

Nominal pipe size (OD Dia.) in.	Schedule No.	Wall Thick. (t) in.	Inside Dia. (d) in.	Area of Metal (a) $in.^2$	Transverse Internal Area $in.^2$	Moment of Inertia (I) $in.^4$	Weight of Pipe lb/ft	Weight of Water lb/ft	External Surface ft^2/ft	Section Modulus (2I/D)
4 (4.5)	40s	0.237	4.026	3.174	12.73	7.233	10.79	5.5	1.178	3.214
	80x	0.337	3.826	4.407	11.5	9.61	14.98	4.98	1.178	4.271
	120	0.438	3.624	5.595	10.31	11.65	19	4.47	1.178	5.178
	160	0.531	3.438	6.621	9.28	13.27	22.51	4.02	1.178	5.898
	...xx	0.674	3.152	8.101	7.8	15.28	27.54	3.38	1.178	6.791
5 (5.563)	40s	0.258	5.047	4.3	20.01	15.16	14.62	8.67	1.456	5.451
	80x	0.375	4.813	6.112	18.19	20.67	20.78	7.88	1.456	7.431
	120	0.5	4.563	7.953	16.35	25.73	27.1	7.09	1.456	9.25
	160	0.625	4.313	9.696	14.61	30.03	32.96	6.33	1.456	10.796
	...xx	0.75	4.063	11.34	12.97	33.63	38.55	5.61	1.456	12.09
6 (6.625)	40s	0.28	6.065	5.581	28.89	28.14	18.97	12.51	1.734	8.5
	80x	0.432	5.761	8.405	26.07	40.49	28.57	11.29	1.734	12.22
	120	0.562	5.501	10.7	23.77	49.61	36.4	10.3	1.734	14.98
	160	0.718	5.189	13.32	21.15	58.97	45.3	9.16	1.734	17.81
	...xx	0.864	4.897	15.64	18.84	66.33	53.16	8.16	1.734	20.02
8 (8.625)	20	0.25	8.125	6.57	51.85	57.52	22.36	22.47	2.258	13.39
	30	0.277	8.071	7.26	51.16	63.35	24.7	22.17	2.258	14.69
	40s	0.322	7.981	8.4	50.03	72.49	28.55	21.7	2.258	16.81
	60	0.406	7.813	10.48	47.94	88.73	35.64	20.77	2.258	20.58
	80x	0.5	7.625	12.76	45.66	105.7	43.39	19.78	2.258	24.51
	100	0.593	7.439	14.96	43.46	121.3	50.87	18.83	2.258	28.14
	120	0.718	7.189	17.84	40.59	140.5	60.63	17.59	2.258	32.58
	140	0.812	7.001	19.93	38.5	153.7	67.76	16.68	2.258	35.65
	...xx	0.875	6.875	21.3	37.12	162	72.42	16.1	2.258	37.56
	160	0.906	6.813	21.97	36.46	156.9	74.69	15.8	2.258	38.48
10 (10.75)	20	0.25	10.25	8.24	82.52	113.7	28.04	35.76	2.814	21.15
	30	0.307	10.136	10.07	80.69	137.4	34.24	34.96	2.814	25.57
	40s	0.365	10.02	11.9	78.86	160.7	40.48	34.2	2.814	29.9
	60x	0.5	9.75	16.1	74.66	212	54.74	32.35	2.814	39.43
	80	0.593	9.564	18.92	71.84	244.8	64.33	31.13	2.814	45.54
	100	0.718	9.314	22.63	68.13	286.1	76.93	29.53	2.814	53.22
	120	0.843	9.064	26.24	64.53	324.2	89.2	27.96	2.814	60.32
	140	1	8.75	30.63	60.13	367.8	104.13	26.06	2.814	68.43
	160	1.125	8.5	34.02	56.75	399.3	115.65	24.59	2.814	74.29

Table 7-1

Nominal pipe size (OD Dia.) in.	Schedule No.	Wall Thick. (t) in.	Inside Dia. (d) in.	Area of Metal (a) in.^{2}	Transverse Internal Area in.^{2}	Moment of Inertia (I) in.^{4}	Weight of Pipe lb/ft	Weight of Water lb/ft	External Surface ft^2/ft	Section Modulus (2I/D)
12 (12.75)	20	0.25	12.25	9.82	117.86	191.8	33.38	51.07	3.338	30.2
	30	0.33	12.09	12.87	114.8	248.4	43.77	49.74	3.338	39
	..s	0.375	12	14.58	113.1	279.3	49.56	49	3.338	43.8
	40	0.406	11.938	15.77	111.93	300.3	53.53	48.5	3.338	47.1
	..x	0.5	11.75	19.24	108.43	361.5	65.42	46.92	3.338	56.7
	60	0.562	11.626	21.52	106.16	400.4	73.16	46	3.338	62.8
	80	0.687	11.376	26.03	101.64	475.1	88.51	44.04	3.338	74.6
	100	0.843	11.064	31.53	96.14	561.6	107.2	41.66	3.338	88.1
	120	1	10.75	36.91	90.76	641.6	125.49	39.33	3.338	100.7
	140	1.125	10.5	41.08	86.59	700.5	133.68	37.52	3.338	109.9
	160	1.312	10.126	47.14	80.53	781.1	160.27	34.89	3.338	122.6
14 (14)	10	0.25	13.5	10.8	143.14	255.3	36.71	62.03	3.665	36.6
	20	0.312	13.376	13.42	140.52	314.4	45.68	60.89	3.665	45
	30s	0.375	13.25	16.05	137.88	372.8	54.57	59.75	3.665	53.2
	40	0.438	13.124	18.66	135.28	429.1	63.37	58.64	3.665	61.3
	..x	0.5	13	21.21	132.73	483.8	72.09	57.46	3.665	69.1
	60	0.593	12.814	24.98	128.96	562.3	84.91	55.86	3.665	80.3
	80	0.75	12.5	31.22	122.72	687.3	106.13	53.18	3.665	98.2
	100	0.937	12.126	38.45	115.49	824.4	130.73	50.04	3.665	117.8
	120	1.093	11.814	44.32	109.62	929.6	150.67	47.45	3.665	132.8
	140	1.25	11.5	50.07	103.87	1027	170.22	45.01	3.665	146.8
	160	1.406	11.188	55.63	98.31	1117	189.12	42.6	3.665	159.6
16 (16)	10	0.25	15.5	12.37	188.69	383.7	42.05	81.74	4.189	48
	20	0.312	15.376	15.38	185.69	473.2	52.36	80.5	4.189	59.2
	30s	0.375	15.25	18.41	182.65	562.1	62.58	79.12	4.189	70.3
	40x	0.5	15	24.35	176.72	731.9	82.77	76.58	4.189	91.5
	60	0.656	14.688	31.62	169.44	932.4	107.5	73.42	4.189	116.6
	80	0.843	14.314	40.14	160.92	1155.8	136.46	69.73	4.189	144.5
	100	1.031	13.938	48.48	152.58	1364.5	164.83	66.12	4.189	170.5
	120	1.218	13.564	56.56	144.5	1555.8	192.29	62.62	4.189	194.5
	140	1.438	13.124	65.78	135.28	1760.3	223.64	58.64	4.189	220
	160	1.593	12.814	72.1	128.96	1893.5	245.11	55.83	4.189	236.7
18 (18)	10	0.25	17.5	13.94	240.53	549.1	47.39	104.21	4.712	61.1
	20	0.312	17.376	17.34	237.13	678.2	59.03	102.77	4.712	75.5
	..s	0.375	17.25	20.76	233.71	806.7	70.59	101.18	4.712	89.6
	30	0.438	17.124	24.17	230.3	930.3	82.06	99.84	4.712	103.4
	..x	0.5	17	27.49	226.98	1053.2	92.45	98.27	4.712	117
	40	0.562	16.876	30.79	223.68	1171.5	104.75	96.93	4.712	130.1
	60	0.75	16.5	40.64	213.83	1514.7	138.17	92.57	4.712	168.3
	80	0.937	16.126	50.23	204.24	1833	170.75	88.5	4.712	203.8
	100	1.156	15.688	61.17	193.3	2180	207.96	83.76	4.712	242.3
	120	1.375	15.25	71.81	182.66	2498.1	244.14	79.07	4.712	277.6
	140	1.562	14.876	80.66	173.8	2749	274.23	75.32	4.712	305.5
	160	1.781	14.438	90.75	163.72	3020	308.51	70.88	4.712	335.6

Nominal pipe size (OD Dia.) in.	Schedule No.	Wall Thick. (t) in.	Inside Dia. (d) in.	Area of Metal (a) in.^{2}	Transverse Internal Area in.^{2}	Moment of Inertia (I) in.^{4}	Weight of Pipe lb/ft	Weight of Water lb/ft	External Surface ft^2/ft	Section Modulus (2I/D)
20 (20)	10	0.25	19.5	15.51	298.65	756.4	52.73	129.42	5.236	75.6
	20s	0.375	19.25	23.12	290.04	1113	78.6	125.67	5.236	111.3
	30x	0.5	19	30.63	283.53	1457	104.13	122.87	5.236	145.7
	40	0.593	18.814	36.15	278	1703	122.91	120.46	5.236	170.4
	60	0.812	18.376	48.95	265.21	2257	166.4	114.92	5.236	225.7
	80	1.031	17.938	61.44	252.72	2772	208.87	109.51	5.236	277.1
	100	1.281	17.438	75.33	238.83	3315.2	256.1	103.39	5.236	331.5
	120	1.5	17	87.18	226.98	3754	296.37	98.35	5.236	375.5
	140	1.75	16.5	100.33	213.82	4216	341.1	92.66	5.236	421.7
	160	1.968	16.064	111.49	202.67	4585.5	379.01	87.74	5.236	458.5
24 (24)	10	0.25	23.5	18.65	433.74	1315.4	63.41	187.95	6.283	109.6
	20s	0.375	23.25	27.83	424.56	1942	94.62	183.95	6.283	161.9
	..x	0.5	23	36.91	415.48	2549.5	125.49	179.87	6.283	212.5
	30	0.562	22.876	41.39	411	2843	140.8	178.09	6.283	237
	40	0.687	22.626	50.31	402.07	3421.3	171.17	174.23	6.283	285.1
	60	0.968	22.064	70.04	382.35	4652.8	238.11	165.52	6.283	387.7
	80	1.218	21.564	87.17	365.22	5672	296.36	158.26	6.283	472.8
	100	1.531	20.938	108.07	344.32	6849.9	367.4	149.06	6.283	570.8
	120	1.812	20.376	126.31	326.08	7825	429.39	141.17	6.283	652.1
	140	2.062	19.876	142.11	310.28	8625	483.13	134.45	6.283	718.9
	160	2.343	19.314	159.41	292.98	9455.9	541.94	126.84	6.283	787.9
30 (30)	10	0.312	29.376	29.1	678	3210	98.93	293.8	7.85	214
	20	0.5	29	46.3	661	5040	157.53	286.3	7.85	336
	30	0.625	28.75	57.6	649	6220	196.08	281.5	7.85	414.67

Properties of Large Diameter Water Supply Piping (King 1967)

ID, in.	Thickness, in.	Pipe weight/ft bare, based on 5% over-weight lb.	Water contents per foot	Moment of inertia about pipe axis, in.^{4}	Section modulus, in.^{3}	Radius of gyration, in.	Max. safe span unstiffened pipe, simply supported 120 deg bearing stress = 5000 psi, ft
30	3/16	65	306 lb 36.72 gal	2025	133	10.673	34
	1/4	87		2717	178	10.695	38
	5/16	108		3418	223	10.718	41
	3/8	130		4127	268	10.74	44
	7/16	152		4845	313	10.762	47
	1/2	173		5572	359	10.785	50
36	3/16	78	441 lb 52.88 gal	3489	191	12.794	34
	1/4	104		4676	256	12.817	39
	5/16	130		5876	320	12.839	42
	3/8	156		7088	385	12.861	45
	7/16	182		8312	450	12.884	48
	1/2	208		9549	516	12.906	51
	9/16	233		10799	581	12.928	53
	5/8	259		12061	647	12.951	54
42	3/16	90	600 lb 71.97 gal	5528	260	14.916	35
	1/4	120		7404	348	14.938	40
	5/16	150		9296	436	14.96	43
	3/8	180		11206	524	14.982	46
	7/16	210		13132	612	15.005	50
	1/2	240		15074	701	15.027	52
	9/16	270		17034	790	15.049	54
	5/8	300		19011	879	15.072	55
48	1/4	134	784 lb 94 gal	11028	454	17.059	40
	5/16	167		13838	569	17.081	43
	3/8	201		16671	683	17.104	46
	7/16	234		19526	799	17.126	50
	1/2	268		22402	914	17.148	52
	9/16	302		25301	1030	17.171	55
	5/8	335		28222	1146	17.193	57
	11/16	369		31165	1262	17.215	59
	3/4	402		34130	1379	17.238	62

Table 7-2

7.2: Resonance test result tables for the two-phase (water, air) fluid flow was as the following:

Total Volume (cm3)	14230

Air%	0	Vol. (cm3)	0
Water%	100	Vol. (cm3)	14230

Sound Vel.	499.92
L (m)	0.11

Freq. (Hz)	2272.36

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
1	55	3190	68	211	2287	23.2	0.5	3.45	4	27.59
2	50	2900	59	207	2287	23.6	0.5	3.45	3.9	26.90
3	45	2610	52	186	2225	24.2	0.5	3.45	3.6	24.83
4	40	2320	48	165	2225	24.4	0.5	3.45	3.4	23.45
5	35	2030	43	146	2212	24.6	1	6.90	3.2	22.07
6	30	1740	43	125	2212	24.7	1.4	9.66	3	20.69
7	25	1450	37	105	2200	24.7	1.7	11.72	2.9	20.00
8	20	1160	37	85	2200	24.7	1.9	13.10	2.8	19.31
9	15	870	41	65	2225	24.7	2	13.79	2.6	17.93
10	10	580	39	45	2187	24.7	2.1	14.48	2.5	17.24
11	5	290	37	25	2237	24.7	2.1	14.48	2.5	17.24
12	0	0	0	0	2225	24.7	2.1	14.48	2.1	14.48
13	55	3190	67	210	2250	25.3	0.5	3.45	4.1	28.28
14	50	2900	59	207	2237	26	0.5	3.45	4.1	28.28
15	45	2610	52	186	2187	26.4	0.5	3.45	4	27.59
16	40	2320	48	165	2187	26.7	1.2	8.28	3.9	26.90
17	35	2030	43	146	2212	26.8	1.8	12.41	3.6	24.83
18	30	1740	42	125	2200	27	1.9	13.10	3.4	23.45
19	25	1450	38	105	2162	26.9	2	13.79	3.2	22.07
20	20	1160	37	85	2212	26.9	2.3	15.86	3.1	21.38
21	15	870	41	65	2212	26.9	2.5	17.24	2.9	20.00
22	10	580	41	45	2212	26.8	2.6	17.93	2.9	20.00
23	5	290	37	25	2225	26.7	2.6	17.93	2.7	18.62
24	0	0	0	0	2200	26.7	2.6	17.93	2.6	17.93

Air%	0.05	Vol. (cm3)	7.12
Water%	99.95	Vol. (cm3)	14222.89

Sound Vel.	364.50
L (m)	0.11

Freq. (Hz)	1656.80

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
25	55	3190	67	211	1775	24.1	0.5	3.45	5.5	37.93
26	50	2900	58	205	1770	24.9	1.4	9.66	5.4	37.24
27	45	2610	52	186	1770	25.3	2	13.79	5.3	36.55
28	40	2320	48	166	1770	25.7	2.4	16.55	5.1	35.17
29	35	2030	43	146	1745	26	2.9	20.00	4.9	33.79
30	30	1740	43	126	1775	26.1	3.1	21.38	4.6	31.72
31	25	1450	39	106	1765	26.2	3.2	22.07	4.5	31.03
32	20	1160	39	86	1795	26.2	3.4	23.45	4.2	28.97
33	15	870	42	65	1765	26.2	3.7	25.52	4.1	28.28
34	10	580	40	45	1775	26.2	3.8	26.21	4.1	28.28
35	5	290	37	25	1775	26.1	3.8	26.21	4	27.59
36	55	3190	67	211	1775	26.6	1.3	8.97	5.9	40.69
37	50	2900	59	208	1770	27.3	2.1	14.48	5.9	40.69
38	45	2610	52	187	1740	27.7	2.7	18.62	5.9	40.69
39	40	2320	48	168	1755	28	3.1	21.38	5.7	39.31
40	35	2030	44	147	1760	28.2	3.6	24.83	5.5	37.93
41	30	1740	43	126	1740	28.2	3.9	26.90	5.3	36.55
42	25	1450	37	106	1755	28.2	4	27.59	5	34.48
43	20	1160	40	86	1770	28.2	4.1	28.28	4.8	33.10
44	15	870	42	65	1775	28.2	4.3	29.66	4.6	31.72
45	10	580	39	45	1770	28	4.2	28.97	4.5	31.03
46	5	290	39	25	1790	27.9	4.2	28.97	4.3	29.66

Air%	0.1	Vol. (cm3)	14.23
Water%	99.9	Vol. (cm3)	14215.77

Sound Vel.	300.84
L (m)	0.11

Freq. (Hz)	1367.47

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
47	55	3190	65	211	1480	24.7	1	6.90	4.4	30.34
48	50	2900	57	207	1465	25.3	1	6.90	4.6	31.72
49	45	2610	52	186	1475	25.6	2	13.79	5	34.48
50	40	2320	49	166	1490	26.1	3	20.69	5.2	35.86
51	35	2030	44	147	1490	26.2	3.5	24.14	5.2	35.86
52	30	1740	43	126	1460	26.3	3.8	26.21	5	34.48
53	25	1450	37	105	1485	26.3	4	27.59	4.7	32.41
54	20	1160	39	85	1410	26.2	4	27.59	4.3	29.66
55	15	870	43	65	1475	26	4	27.59	4.1	28.28
56	10	580	37	45	1410	25.9	3.9	26.90	3.9	26.90
57	5	290	38	25	1485	25.9	3.8	26.21	3.7	25.52
58	55	3190	66	211	1495	24.5	1	6.90	3.1	21.38
59	50	2900	58	207	1460	25.1	1	6.90	3	20.69
60	45	2610	53	187	1455	25.4	1	6.90	2.9	20.00
61	40	2320	49	166	1450	26	1	6.90	2.8	19.31
62	35	2030	44	147	1420	26.2	1	6.90	2.7	18.62
63	30	1740	44	126	1465	26.3	1	6.90	2.6	17.93
64	25	1450	39	105	1440	26.2	1.5	10.34	2.5	17.24
65	20	1160	39	85	1425	26.1	1.7	11.72	2.4	16.55
66	15	870	42	65	1385	25.9	1.8	12.41	2.3	15.86
67	10	580	39	45	1450	25.7	1.9	13.10	2.2	15.17
68	5	290	38	25	1455	25.6	2	13.79	2.1	14.48

Air%	0.15	Vol. (cm3)	21.35
Water%	99.85	Vol. (cm3)	14208.655

Sound Vel.	262.00
L (m)	0.11

Freq. (Hz)	1190.93

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
69	55	3190	68	211	1415	25.6	0.5	3.45	2	13.79
70	50	2900	59	207	1390	26.2	0.5	3.45	1.8	12.41
71	45	2610	52	186	1380	26.5	0.5	3.45	1.6	11.03
72	40	2320	48	166	1395	26.7	0.5	3.45	1.5	10.34
73	35	2030	43	147	1415	26.8	0.5	3.45	1.3	8.97
74	30	1740	43	126	1380	27	0.5	3.45	1.1	7.59
75	25	1450	39	106	1405	27	0.5	3.45	1.1	7.59
76	20	1160	38	86	1395	27	0.5	3.45	1	6.90
77	15	870	42	65	1390	27	0.5	3.45	1	6.90
78	10	580	43	45	1380	26.9	0.5	3.45	0.9	6.21
79	5	290	37	25	1385	26.9	0.5	3.45	0.9	6.21
80	55	3190	67	211	1420	27.5	0.5	3.45	2.5	17.24
81	50	2900	58	207	1385	28	0.5	3.45	2.1	14.48
82	45	2610	52	186	1410	28.3	0.5	3.45	2	13.79
83	40	2320	47	166	1400	28.5	0.5	3.45	1.8	12.41
84	35	2030	43	146	1380	28.8	0.5	3.45	1.6	11.03
85	30	1740	43	126	1385	29	0.5	3.45	1.5	10.34
86	25	1450	38	105	1380	29	0.5	3.45	1.4	9.66
87	20	1160	38	85	1370	29	1	6.90	1.5	10.34
88	15	870	42	65	1390	29	1.5	10.34	1.5	10.34
89	10	580	39	45	1415	28.9	1.5	10.34	1.5	10.34
90	5	290	40	25	1420	28.9	1.5	10.34	1.5	10.34

Air%	0.2	Vol. (cm3)	28.46
Water%	99.8	Vol. (cm3)	14201.54

Sound Vel.	235.16
L (m)	0.11

Freq. (Hz)	1068.93

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
91	55	3190	67	211	1340	26.3	0.5	3.45	1.7	11.72
92	50	2900	58	207	1355	27	0.5	3.45	1.5	10.34
93	45	2610	53	187	1385	27.3	0.5	3.45	1.5	10.34
94	40	2320	48	166	1350	27.6	0.5	3.45	1.4	9.66
95	35	2030	44	146	1345	27.7	0.5	3.45	1.3	8.97
96	30	1740	43	125	1340	27.8	0.5	3.45	1.2	8.28
97	25	1450	37	105	1330	27.8	0.5	3.45	1.1	7.59
98	20	1160	38	85	1310	27.8	0.5	3.45	1.1	7.59
99	15	870	42	65	1350	27.8	0.5	3.45	0.9	6.21
100	10	580	43	45	1360	27.7	0.5	3.45	0.9	6.21
101	55	3190	66	210	1360	28	0.5	3.45	2.1	14.48
102	50	2900	58	205	1320	28.4	0.5	3.45	1.8	12.41
103	45	2610	52	186	1300	28.8	0.5	3.45	1.6	11.03
104	40	2320	47	166	1310	29.1	0.5	3.45	1.5	10.34
105	35	2030	42	146	1310	29.2	0.5	3.45	1.5	10.34
106	30	1740	43	125	1275	29.2	0.5	3.45	1.4	9.66
107	25	1450	41	105	1270	29.2	0.5	3.45	1.4	9.66
108	20	1160	38	85	1260	29.2	0.5	3.45	1.3	8.97
109	15	870	43	65	1180	29.2	1	6.90	1.2	8.28
110	10	580	41	45	1160	29.1	1	6.90	1	6.90

Air%	0.25	Vol. (cm3)	35.58
Water%	99.75	Vol. (cm3)	14194.425

Sound Vel.	215.20
L (m)	0.11

Freq. (Hz)	978.16

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
111	55	3190	69	210	560	23.9	0.5	3.45	2	13.79
112	50	2900	60	207	557	24.3	0.5	3.45	1.8	12.41
113	45	2610	53	187	557	24.6	0.5	3.45	1.7	11.72
114	40	2320	48	166	560	24.8	0.5	3.45	1.5	10.34
115	35	2030	43	146	557	25	0.5	3.45	1.4	9.66
116	30	1740	42	126	550	25.1	0.5	3.45	1.2	8.28
117	25	1450	37	105	552	25.2	0.5	3.45	1.1	7.59
118	20	1160	37	85	543	25.2	0.5	3.45	1	6.90
119	55	3190	68	210	552	25.5	0.5	3.45	2.4	16.55
120	50	2900	59	205	550	25.9	0.5	3.45	2.3	15.86
121	45	2610	52	186	555	26.3	0.5	3.45	2	13.79
122	40	2320	47	166	547	26.6	0.5	3.45	1.8	12.41
123	35	2030	43	146	560	26.7	0.5	3.45	1.6	11.03
124	30	1740	42	125	550	26.8	0.5	3.45	1.5	10.34
125	25	1450	37	105	557	26.8	0.5	3.45	1.4	9.66
126	20	1160	38	85	545	26.7	0.5	3.45	1.2	8.28

Air%	0.3	Vol. (cm3)	42.69
Water%	99.7	Vol. (cm3)	14187.31

Sound Vel.	199.59
L (m)	0.11

Freq. (Hz)	907.24

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
127	55	3190	67	210	525	24.1	0.5	3.45	2	13.79
128	50	2900	58	205	542	24.7	0.5	3.45	1.8	12.41
129	45	2610	53	186	532	25.1	0.5	3.45	1.6	11.03
130	40	2320	48	166	540	25.3	0.5	3.45	1.5	10.34
131	35	2030	43	146	540	25.5	0.5	3.45	1.3	8.97
132	30	1740	42	126	540	25.6	0.5	3.45	1.2	8.28
133	25	1450	38	105	532	25.7	0.5	3.45	1.1	7.59
134	20	1160	38	85	550	25.7	0.5	3.45	1	6.90
135	55	3190	67	210	540	26	0.5	3.45	2.5	17.24
136	50	2900	58	207	545	26.5	0.5	3.45	2	13.79
137	45	2610	53	187	542	26.8	0.5	3.45	1.9	13.10
138	40	2320	48	166	545	27.1	0.5	3.45	1.7	11.72
139	35	2030	44	147	535	27.2	0.5	3.45	1.6	11.03
140	30	1740	44	126	540	27.2	0.5	3.45	1.3	8.97
141	25	1450	38	105	540	27.3	0.5	3.45	1.3	8.97
142	20	1160	38	86	530	27.3	0.5	3.45	1.1	7.59

Air%	0.5	Vol. (cm3)	71.15
Water%	99.5	Vol. (cm3)	14158.85

Sound Vel.	159.93
L (m)	0.12

Freq. (Hz)	666.36

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
143	55	3190	67	210	443	27.3	0.5	3.45	2.2	15.17
144	50	2900	58	207	448	28.3	0.5	3.45	2.1	14.48
145	45	2610	52	186	441	30.9	0.5	3.45	2.4	16.55
146	40	2320	49	166	441	31.3	0.5	3.45	2.3	15.86
147	35	2030	43	146	425	31.4	0.5	3.45	2.1	14.48
148	30	1740	43	126	422	31.5	0.5	3.45	2	13.79
149	25	1450	40	105	420	31.5	1.2	8.28	1.9	13.10
150	55	3190	66	210	445	32.6	0.5	3.45	3.1	21.38
151	50	2900	58	207	447	33.1	0.5	3.45	3	20.69
152	45	2610	52	186	423	33.5	0.5	3.45	2.8	19.31
153	40	2320	48	166	417	33.6	0.5	3.45	2.7	18.62
154	35	2030	44	146	421	33.7	1.2	8.28	2.5	17.24
155	30	1740	43	125	433	33.7	1.5	10.34	2.5	17.24
156	25	1450	38	105	443	33.7	1.8	12.41	2.4	16.55

Air%	0.8	Vol. (cm3)	113.84
Water%	99.2	Vol. (cm3)	14116.16

Sound Vel.	129.11
L (m)	0.11

Freq. (Hz)	586.88

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
157	55	3190	66	208	420	28.4	0.5	3.45	1.9	13.10
158	50	2900	57	207	415	29	0.5	3.45	1.7	11.72
159	45	2610	53	187	421	29.3	0.5	3.45	1.5	10.34
160	40	2320	48	166	415	29.7	0.5	3.45	1.4	9.66
161	35	2030	44	147	421	29.8	0.5	3.45	1.3	8.97
162	30	1740	44	126	417	29.8	0.5	3.45	1.1	7.59
163	55	3190	66	211	417	30.2	0.5	3.45	2.3	15.86
164	50	2900	57	207	421	30.7	0.5	3.45	2.1	14.48
165	45	2610	52	186	417	31.1	0.5	3.45	1.9	13.10
166	40	2320	48	166	410	31.3	0.5	3.45	1.7	11.72
167	35	2030	44	146	420	31.5	0.5	3.45	1.5	10.34
168	30	1740	43	125	415	31.5	0.5	3.45	1.5	10.34

Air%	1	Vol. (cm3)	142.3
Water%	99	Vol. (cm3)	14087.7

Sound Vel.	116.37
L (m)	0.11

Freq. (Hz)	528.96

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
169	55	3190	66	214	432	26.2	0.5	3.45	2	13.79
170	50	2900	58	210	442	26.7	0.5	3.45	1.7	11.72
171	45	2610	53	190	462	27.2	0.5	3.45	1.5	10.34
172	40	2320	49	169	462	27.4	0.5	3.45	1.4	9.66
173	35	2030	45	147	457	27.6	0.5	3.45	1.3	8.97
174	30	1740	45	127	457	27.6	0.5	3.45	1.1	7.59
175	55	3190	67	211	415	24.8	0.5	3.45	2	13.79
176	50	2900	58	208	410	25.3	0.5	3.45	1.9	13.10
177	45	2610	53	187	415	25.7	0.5	3.45	1.6	11.03
178	40	2320	48	166	410	25.8	0.5	3.45	1.5	10.34
179	35	2030	44	147	405	26	0.5	3.45	1.2	8.28
180	30	1740	43	126	407	26.1	0.5	3.45	1.1	7.59

Air%	2	Vol. (cm3)	284.6
Water%	98	Vol. (cm3)	13945.4

Sound Vel.	83.84
L (m)	0.12

Freq. (Hz)	349.32

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
181	55	3190	65	210	407	27.6	0.5	3.45	2.4	16.55
182	50	2900	57	207	393	28.1	0.5	3.45	2	13.79
183	45	2610	52	186	406	28.6	0.5	3.45	1.9	13.10
184	40	2320	47	166	406	28.7	0.5	3.45	1.7	11.72
185	35	2030	43	146	402	28.8	0.5	3.45	1.5	10.34
186	30	1740	42	125	400	28.9	0.5	3.45	1.3	8.97
187	55	3190	65	210	397	29.7	0.5	3.45	2.5	17.24
188	50	2900	57	205	403	30.5	0.5	3.45	2.3	15.86
189	45	2610	51	186	401	30.8	0.5	3.45	2	13.79
190	40	2320	48	165	406	31	0.5	3.45	2	13.79
191	35	2030	43	145	406	31.1	0.5	3.45	1.8	12.41
192	30	1740	42	125	407	31.1	0.5	3.45	1.6	11.03

Air%	3	Vol. (cm3)	426.9
Water%	97	Vol. (cm3)	13803.1

Sound Vel.	69.12
L (m)	0.12

Freq. (Hz)	288.01

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
193	55	3190	64	210	397	26.3	0.5	3.45	2	13.79
194	50	2900	56	207	401	26.9	0.5	3.45	1.7	11.72
195	45	2610	51	186	398	27.5	0.5	3.45	1.5	10.34
196	40	2320	47	165	397	27.8	0.5	3.45	1.3	8.97
197	35	2030	42	146	401	28	0.5	3.45	1.1	7.59
198	55	3190	63	210	410	28.6	0.5	3.45	2	13.79
199	50	2900	55	205	412	30	0.5	3.45	2	13.79
200	45	2610	50	186	406	30.3	0.5	3.45	1.9	13.10
201	40	2320	47	166	396	30.5	0.5	3.45	1.7	11.72
202	35	2030	42	147	395	30.6	0.5	3.45	1.4	9.66

Air%	4	Vol. (cm3)	569.2
Water%	96	Vol. (cm3)	13660.8

Sound Vel.	60.31
L (m)	0.11

Freq. (Hz)	274.15

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
203	55	3190	58	210	390	27	0.5	3.45	1.8	12.41
204	50	2900	53	205	386	27.8	0.5	3.45	1.5	10.34
205	45	2610	49	185	398	28.1	0.5	3.45	1.4	9.66
206	40	2320	46	165	402	28.3	0.5	3.45	1.3	8.97
207	55	3190	59	211	396	28.8	0.5	3.45	1.6	11.03
208	50	2900	54	208	393	29.2	0.5	3.45	1.4	9.66
209	45	2610	50	187	397	29.5	0.5	3.45	1.2	8.28
210	40	2320	47	168	400	29.6	0.5	3.45	1.2	8.28

Air%	5	Vol. (cm3)	711.5
Water%	95	Vol. (cm3)	13518.5

Sound Vel.	54.30
L (m)	0.11

Freq. (Hz)	246.83

							Suction Press.		Discharge Press.	
Test	Hz	RPM	Load%	Volt	Reson. F.	Temp. C	PSI	Kpa	PSI	Kpa
211	55	3190	57	211	395	27.3	0.5	3.45	1.8	12.41
212	50	2900	52	207	397	27.8	0.5	3.45	1.7	11.72
213	45	2610	48	187	396	28.2	0.5	3.45	1.5	10.34
214	55	3190	57	211	396	28.8	0.5	3.45	1.9	13.10
215	50	2900	52	207	396	29.5	0.5	3.45	1.8	12.41
216	45	2610	48	187	397	30	0.5	3.45	1.6	11.03

7.3 : Resonance test result tables for the three phase (water, air, solid) fluid flow was as the following:

Tot. Vol. (cm3)	17910

						R=C/2L	
Poly beads%	5	Vol. (cm3)	895.5	Sound Vel.	486.172719	Res. (Hz)	2209.876
Air%	0	Vol. (cm3)	0	L (m)	0.11		
Water%	95	Vol. (cm3)	17014.5				
		Tot.Vol. (cm3)	17910				

Test #	Hz	RPM	Reson. Hz	Temp. C	Suc.Pre. psi	Dis.Pre. psi
1	45	2700	1962	26	1	2
2	40	2400	1975	26.5	1	2
3	35	2100	1970	26.7	1	2
4	30	1800	1970	26.7	1	2
5	25	1500	1960	26.8	1	2
6	20	1200	1963	26.8	1	2
7	15	900	1965	26.8	1	2
8	45	2700	1965	26.9	1	2
9	40	2400	1962	27.1	1	2
10	35	2100	1970	27.3	1	2
11	30	1800	1972	27.6	1	2
12	25	1500	1965	27.7	1	2
13	20	1200	1962	27.7	1	2
14	15	900	1965	27.6	1	2

Tot. Vol. (cm3)	17910

						R=C/2L	
Poly beads%	5	Vol. (cm3)	895.5	Sound Vel.	358.862153	Freq. (Hz)	1631.192
Air%	0.05	Vol. (cm3)	8.955	L (m)	0.11		
Water%	94.95	Vol. (cm3)	17005.55				
		Tot.Vol. (cm3)	17910				

Test #	Hz	RPM	Reson. Hz	Temp. C	Suc.Pre. psi	Dis.Pre. psi
15	45	2700	1440	25.7	1.5	2.6
16	40	2400	1445	26.3	1.5	2.6
17	35	2100	1443	26.5	1.5	2.6
18	30	1800	1446	26.5	1.5	2.6
19	25	1500	1450	26.6	1.5	2.6
20	20	1200	1445	26.6	1.5	2.6
21	15	900	1443	26.7	1.5	2.6
22	45	2700	1442	26.7	1.5	2.6
23	40	2400	1445	26.8	1.5	2.6
24	35	2100	1452	27.1	1.5	2.6
25	30	1800	1448	27.2	1.5	2.6
26	25	1500	1445	27.4	1.5	2.6
27	20	1200	1443	27.4	1.5	2.6
28	15	900	1443	27.3	1.5	2.6

Tot. Vol. (cm3)	17910

						R=C/2L	
Poly beads%	5	Vol. (cm3)	895.5	Sound Vel.	297.537013	Freq. (Hz)	1352.441
Air%	0.1	Vol. (cm3)	17.91	L (m)	0.11		
Water%	94.9	Vol. (cm3)	16996.59				
		Tot.Vol. (cm3)	17910				

Test #	Hz	RPM	Reson. Hz	Temp. C	Suc.Pre. psi	Dis.Pre. psi
29	45	2700	1180	22	1.5	3
30	40	2400	1183	22.4	1.5	3
31	35	2100	1186	22.6	1.5	3
32	30	1800	1185	22.7	1.5	2.8
33	25	1500	1185	22.8	1.5	2.8
34	20	1200	1187	22.9	1.5	2.7
35	15	900	1185	24	1.5	2.6
36	45	2700	1182	24	1.5	3
37	40	2400	1185	24.2	1.5	3
38	35	2100	1190	24	1.5	2.9
39	30	1800	1190	23.7	1.5	2.8
40	25	1500	1186	23.5	1.5	2.8
41	20	1200	1183	23.4	1.5	2.7
42	15	900	1183	23.4	1.5	2.7

7.4 : Sound Level Measurement at North Mine

7.4.1: Ambient

Ambient Sound Level Spectrum, North Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	72.9	79.1	64.4	83
16	75.4	79.4	69.3	85.5
20	85.3	95.2	69.7	95.4
25	76.8	84.3	67.4	86.9
31.5	79.6	86.6	68.2	89.7
40	79.8	86.6	70.4	89.9
50	70	76.1	59.9	80
63	66.1	72.3	59.2	76.2
80	72.2	75.3	67.8	82.2
100	68.1	70.4	65.9	78.2
125	66.2	71.2	63.3	76.3
160	68.3	73.4	64.4	78.3
200	62.2	65.2	60.7	72.2
250	58	60.3	55.4	68.1
315	59.2	63.7	54.7	69.3
400	54.1	55.8	52.4	64.2
500	50.4	53.9	47.6	60.5
630	51.8	55.8	47.6	61.9
800	56.6	66.7	51.3	66.7
1,000	56.7	61.4	51.3	66.8
1,250	48	53.6	45.3	58.1
1,600	46.7	48.3	45.3	56.8
2,000	51.8	59.2	42.7	61.8
2,500	56.7	62.9	44.9	66.8
3,150	51.9	58.1	46.8	62
4,000	50.7	56.6	46.1	60.8
5,000	51.6	56.6	46.4	61.6
6,300	45.1	47.9	43.1	55.1
8,000	52.4	55.1	48.3	62.5
10,000	52.8	58.8	49.8	62.9
12,500	52.8	59.9	44.9	62.9
16,000	46.6	50.6	43.4	56.7
20,000	41.5	46.4	36.7	51.6

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	84	88.4	79.1	94.1
16	84.6	89.2	79.4	94.7
20	84.8	88.4	80.2	94.9
25	82.4	85.8	77.9	92.5
31.5	81.3	86.8	74.6	91.4
40	75.8	82.1	69.3	85.8
50	71.7	74.9	67.4	81.8
63	74.2	80.9	62.6	84.3
80	75.3	80.9	70.1	85.4
100	68.8	72.7	64.8	78.9
125	74.8	77.6	68.2	84.9
160	72.2	77.2	67.1	82.3
200	63.1	65.6	61.1	73.1
250	62	67.1	58.1	72.1
315	60.9	65.2	56.9	71
400	60.9	62.9	57.7	71
500	64.7	71.9	56.9	74.8
630	54.5	57.7	49.8	64.6
800	50.1	52.1	47.9	60.2
1,000	47.7	50.6	45.7	57.8
1,250	50.1	52.4	47.2	60.2
1,600	50	53.6	44.9	60.1
2,000	49.6	55.1	45.7	59.6
2,500	44.3	48.3	41.6	54.4
3,150	45.6	48.3	44.2	55.7
4,000	45.6	47.6	44.2	55.6
5,000	44.2	46.1	43.4	54.3
6,300	45.5	51.3	41.9	55.6
8,000	49.8	51.3	48.3	59.9
10,000	50.1	52.4	49.1	60.2
12,500	45.5	51.3	41.6	55.6
16,000	47.2	54.7	43.1	57.3
20,000	44.4	49.4	36.7	54.5

Test 3

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	82.2	86.9	73.8	92.3
16	85.2	89.6	79.4	95.3
20	92.1	97.8	84.7	102.2
25	75.9	80.6	64.8	86
31.5	85.9	94.8	75.3	96
40	67.7	71.2	64.8	77.8
50	63.6	68.2	58.8	73.7
63	62	64.4	59.2	72
80	68.8	72.3	66.7	78.9
100	66.8	70.8	64.8	76.9
125	67.7	69.7	65.2	77.8
160	65.5	68.6	62.9	75.6
200	59.9	61.8	58.1	70
250	57.1	58.4	55.8	67.2
315	54.3	56.2	52.4	64.4
400	53.4	56.2	50.9	63.5
500	50	52.1	47.9	60
630	46.4	49.4	44.9	56.5
800	47.9	49.4	46.1	58
1,000	46.5	48.3	45.7	56.6
1,250	46.7	48.3	44.9	56.8
1,600	44.9	46.8	43.4	55
2,000	44	46.8	41.9	54.1
2,500	40.9	43.1	39.3	51
3,150	45.4	48.7	42.7	55.5
4,000	45.4	46.4	44.6	55.4
5,000	44.8	46.4	43.4	54.9
6,300	43.3	44.8	42.3	53.3
8,000	48.6	49.4	47.2	58.7
10,000	49.3	50.6	48.3	59.4
12,500	41.2	44.6	38.6	51.2
16,000	42.8	43.8	40.8	52.8
20,000	35.9	38.9	34.1	46

Test 4

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	76.6	83.6	66.3	86.7
16	71.8	76.1	67.1	81.9
20	67	71.6	61.1	77.1
25	65	68.9	60.3	75.1
31.5	72	79.8	61.4	82.1
40	67.1	73.1	58.8	77.2
50	63.7	70.4	60.3	73.7
63	68.5	75.7	60.3	78.6
80	68.5	72.3	64.4	78.5
100	68.5	70.4	65.2	78.5
100	68.5	70.4	65.2	78.5
160	69.3	72.7	61.8	79.3
200	62.7	65.6	60.7	72.8
250	60.1	61.8	58.1	70.2
315	57.4	59.9	55.4	67.5
400	57.6	62.6	54.7	67.6
500	49.7	51.7	48.3	59.7
630	47.1	48.7	45.7	57.2
800	49.3	52.1	47.2	59.4
1,000	48.3	50.2	47.2	58.3
1,250	49.2	50.6	47.6	59.3
1,600	49	50.9	46.4	59
2,000	47.9	49.4	46.8	57.9
2,500	44.8	46.8	43.1	54.9
3,150	45.1	47.6	43.8	55.2
4,000	45.6	47.2	43.8	55.7
5,000	44.7	46.4	43.4	54.8
6,300	44.1	46.4	43.1	54.2
8,000	49.3	50.2	47.9	59.4
10,000	50	51.3	49.1	60.1
12,500	40.8	45.3	38.5	50.8
16,000	43	44.2	41.2	53
20,000	37	48.1	35.6	47.1

Test 5

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	70.1	74.9	65.2	80.2
16	72.8	77.6	68.2	82.8
20	72.2	77.2	67.1	82.2
25	71.7	77.2	66.7	81.8
31.5	78.3	83.6	64.4	88.3
40	70.9	74.2	67.8	80.9
50	65.8	69.3	61.8	75.9
63	68.4	73.1	62.6	78.5
80	66	70.4	61.1	76.1
100	64.2	67.4	62.2	74.2
125	62.7	64.4	61.4	72.8
160	62.5	65.9	60.3	72.6
200	58.1	60.3	55.8	68.1
250	54.8	57.3	53.2	64.9
315	51.7	54.7	49.8	61.8
400	50.8	52.4	49.4	60.9
500	50.2	54.7	46.8	60.3
630	46.9	49.1	45.7	56.9
800	48.5	49.8	46.8	58.5
1,000	47.8	49.4	46.1	57.9
1,250	48.2	49.8	46.8	58.3
1,600	46.4	48.3	45.3	56.4
2,000	45.3	46.8	44.2	55.3
2,500	42	43.1	40.8	52.1
3,150	44.6	45.7	43.1	54.7
4,000	45.5	46.4	44.6	55.6
5,000	44.5	45.7	43.4	54.6
6,300	43	44.2	42.3	53.1
8,000	49.3	50.2	47.6	59.3
10,000	49.9	51.3	48.7	59.9
12,500	42.8	47.2	38.9	52.8
16,000	43.4	44.9	42.7	53.4
20,000	42.5	48.3	37.8	52.6

Test 6

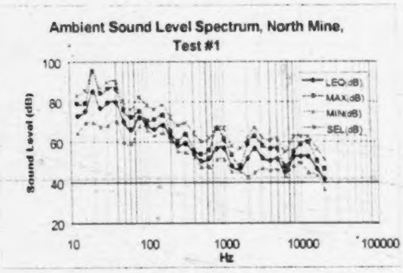
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	76.5	80.9	68.9	86.5
16	67.1	72.7	60.7	77.2
20	70	76.1	58.8	80
25	63.7	67.8	57.7	73.8
31.5	74.4	82.7	59.6	84.5
40	74.6	79.4	66.7	84.6
50	67.4	70.4	60.7	77.4
63	63.1	65.2	61.1	73.1
80	74.1	82.4	62.6	84.2
100	61.8	65.6	58.8	71.9
125	61.3	63.7	59.6	71.3
160	64.8	68.9	59.9	74.9
200	62.1	64.8	58.4	72.2
250	57.9	59.9	56.6	68
315	53.1	55.1	51.3	63.2
400	55.1	59.2	51.7	65.1
500	55.7	60.3	50.6	65.7
630	51.4	56.6	46.8	61.5
800	53.1	58.4	47.9	63.2
1,000	49.1	52.8	45.7	59.2
1,250	53	61.1	46.8	63.1
1,600	54.3	57.7	48.3	64.3
2,000	44	47.9	41.6	54.1
2,500	41.5	44.2	40.1	51.6
3,150	44.2	45.3	42.3	54.3
4,000	45.6	46.8	43.8	55.7
5,000	45	46.8	43.4	55.1
6,300	43.1	44.2	41.9	53.1
8,000	49.4	50.6	47.6	59.5
10,000	49.9	51.3	48.7	59.9
12,500	43	47.6	38.9	53
16,000	44	47.9	41.6	54
20,000	41.9	46.8	37.1	51.9

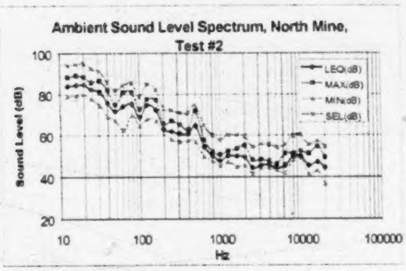
Test 7

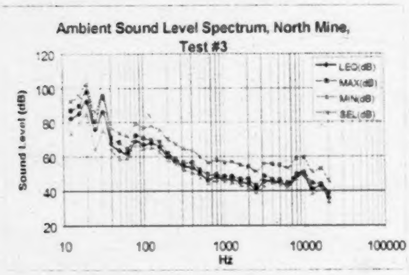
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	76.6	80.6	73.1	86.7
16	79.6	85.1	67.4	89.7
20	73.4	80.6	67.4	83.5
25	71.7	79.1	65.6	81.8
31.5	73.9	77.2	70.8	84
40	70.5	73.8	67.1	80.6
50	66.4	70.4	62.6	76.5
63	70.2	76.8	63.7	80.3
80	66.6	70.4	62.6	76.7
100	64.4	70.8	61.1	74.5
125	67.5	71.2	64.8	77.6
160	65.8	68.6	63.7	75.9
200	61.4	63.7	59.9	71.4
250	58.1	59.9	56.9	68.2
315	54.1	56.2	52.4	64.1
400	52.8	55.4	49.8	62.9
500	47.3	49.8	45.3	57.4
630	45.6	47.6	44.6	55.7
800	51.3	55.8	46.4	61.3
1,000	47.2	50.2	45.7	57.3
1,250	48.5	50.6	47.2	58.6
1,600	45.7	49.1	44.2	55.8
2,000	44	46.1	42.3	54.1
2,500	39.5	41.9	37.8	49.6
3,150	44.9	46.4	42.3	55
4,000	45.6	46.8	44.2	55.7
5,000	44.2	45.3	43.4	54.3
6,300	43.2	45.3	41.9	53.3
8,000	49.6	50.9	47.9	59.7
10,000	50.2	51.3	49.1	60.3
12,500	40	44.9	37.8	50.1
16,000	44.5	48.3	41.2	54.6
20,000	43	50.6	37.4	53.1

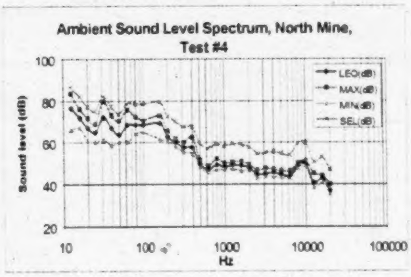
Test 8

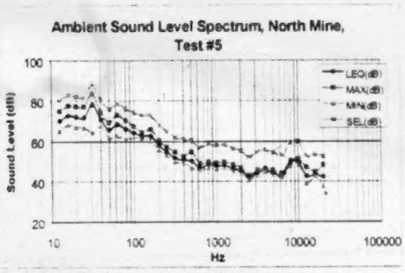
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	85.4	92.9	68.2	95.5
16	71.5	77.2	66.3	81.6
20	78.1	84.7	64.4	88.1
25	72.8	77.9	65.2	82.9
31.5	74.8	79.8	64.9	82.6
40	70.6	78.2	64.6	81.6
50	69	72.7	64.1	79.1
63	66.3	70.8	59.9	76.4
80	68.5	73.8	60.3	78.5
100	63.5	68.2	60.7	73.5
125	61.3	62.9	58.8	71.3
160	59.5	61.1	58.8	69.6
200	59.4	63.3	56.6	69.5
250	57.5	61.1	54.7	67.5
315	54.5	59.6	52.4	64.6
400	53.3	56.6	50.6	63.3
500	51.7	55.4	49.4	61.8
630	46.6	49.4	45.3	56.7
800	45.8	47.6	43.8	55.9
1,000	44.3	45.7	43.4	54.3
1,250	45	48.7	43.1	55.1
1,600	44.2	46.4	42.7	54.3
2,000	42.5	43.8	41.2	52.6
2,500	40.2	41.9	38.9	50.3
3,150	43.9	45.3	41.6	54
4,000	45.2	46.4	43.1	55.3
5,000	44.5	45.7	43.8	54.6
6,300	43	44.2	42.3	53.1
8,000	49.5	50.6	47.9	59.6
10,000	49.7	50.9	48.7	59.8
12,500	41.6	45.7	38.9	51.7
16,000	44.2	49.1	42.3	54.3
20,000	36.2	39.3	34.4	46.3

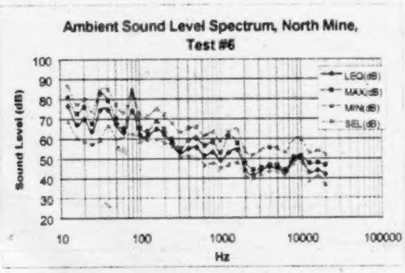

Ambient Sound Level Spectrum, North Mine, Test #1
Sound Level (dB)
100
80
60
40
20
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

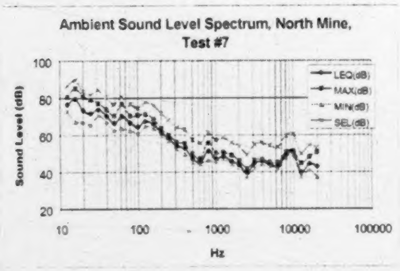

Ambient Sound Level Spectrum, North Mine, Test #2
Sound Level (dB)
100
80
60
40
20
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

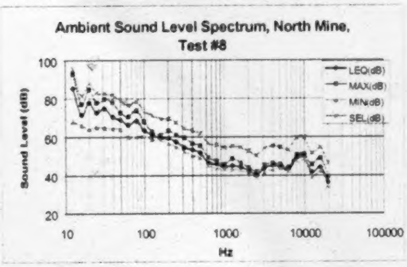

Ambient Sound Level Spectrum, North Mine, Test #3
Sound Level (dB)
120
100
80
60
40
20
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Ambient Sound Level Spectrum, North Mine, Test #4
Sound level (dB)
100
80
60
40
20
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Ambient Sound Level Spectrum, North Mine, Test #5
Sound Level (dB)
100
80
60
40
20
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Ambient Sound Level Spectrum, North Mine, Test #6
Sound Level (dB)
100
90
80
70
60
50
40
30
20
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

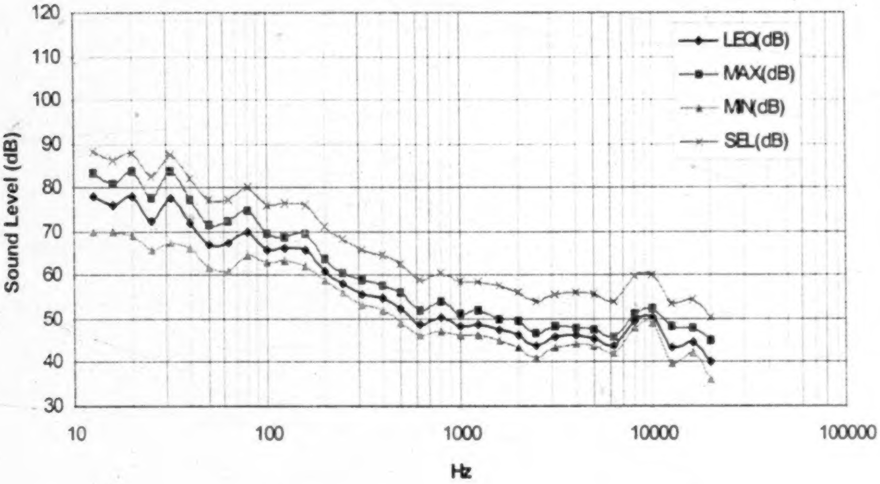

Ambient Sound Level Spectrum, North Mine, Test #7
Sound Level (dB)
100
80
60
40
20
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Ambient Sound Level Spectrum, North Mine, Test #8
Sound Level (dB)
100
80
60
40
20
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Average Ambient Sound Level Spectrum, North Mine

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	78.0	83.4	69.9	88.1
16	76.0	80.9	69.7	86.1
20	77.9	84.0	69.2	87.9
25	72.5	77.7	65.7	82.6
31.5	77.5	83.9	67.4	87.3
40	72.1	77.3	66.2	82.3
50	67.2	71.6	62.0	77.3
63	67.4	72.4	61.1	77.4
80	70.0	74.7	64.5	80.1
100	65.8	69.5	62.9	75.8
125	66.3	68.9	63.3	76.3
160	66.0	69.6	62.4	76.1
200	61.1	63.8	58.9	71.2
250	58.2	60.7	56.1	68.3
315	55.7	58.8	53.2	65.7
400	54.8	57.6	52.2	64.8
500	52.5	56.2	49.1	62.5
630	48.8	51.8	46.3	58.9
800	50.3	54.0	47.2	60.4
1000	48.5	51.1	46.4	58.5
1250	48.6	51.9	46.1	58.7
1600	47.7	50.1	45.1	57.7
2000	46.1	49.4	43.3	56.2
2500	43.7	46.5	40.8	53.8
3150	45.7	48.2	43.4	55.8
4000	46.2	48.0	44.3	56.2
5000	45.4	47.4	43.8	55.5
6300	43.8	46.0	42.4	53.9
8000	49.7	51.0	47.8	59.8
10000	50.2	52.2	48.9	60.3
12500	43.5	48.3	39.8	53.5
16000	44.5	47.9	42.0	54.5
20000	40.3	45.0	36.2	50.4
Overall	84.6	90.2	77.4	94.7

Average Ambient Sound Level Spectrum, North Mine



7.4.2: Pipeline side

Sound Level Spectrum of 27" Slurry Pipeline
(side + ambient) at North Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	92	96.7	82.8	102.1
16	94.4	101.6	85.4	104.6
20	97.4	102.7	90.7	107.5
25	89	94.4	83.6	99.1
31.5	90.6	97.4	82.4	100.7
40	90.7	95.2	85.4	100.9
50	88.9	95.2	81.3	99.1
63	94.9	98.2	89.9	105
80	91	96.3	81.3	101.1
100	78.8	84.7	74.6	88.9
125	78.4	82.8	71.2	88.5
160	80.9	84.3	76.8	91
200	75.7	79.4	71.2	85.9
250	80.6	85.1	71.6	90.7
315	74.4	80.2	67.8	84.6
400	69.7	74.2	65.9	79.8
500	71.9	76.4	67.8	82
630	69.5	74.9	61.4	79.6
800	69.3	72.7	65.2	79.4
1,000	64.6	67.4	62.6	74.8
1,250	63.6	65.2	62.2	73.7
1,600	66.5	68.9	63.7	76.6
2,000	64.7	66.3	62.6	74.8
2,500	63	66.1	60.2	73.1
3,150	60.5	62.4	58.6	70.6
4,000	58.8	61.3	57.4	68.9
5,000	57.9	59.9	55.9	68
6,300	60.5	61.8	59.2	70.6
8,000	59.6	61.4	57.7	69.8
10,000	57.2	60.9	55.2	67.3
12,500	58.4	61.8	55.9	68.5
16,000	56.1	57.7	55.1	66.2
20,000	49.3	51.7	47.2	59.4

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	95.3	99.7	86.6	105.4
16	95.6	99.7	91.1	105.7
20	92.3	97.4	84.7	102.5
25	90	95.6	83.6	100.1
31.5	91.9	97.4	88.4	102
40	93.1	97.1	88.1	103.2
50	93.4	96.7	88.1	103.5
63	88.7	92.6	82.8	98.8
80	87.3	92.9	79.8	97.4
100	86.5	90.3	82.1	96.6
125	90.6	97.8	77.9	100.8
160	91.4	97.8	76.8	101.5
200	87.4	93.7	76.4	97.6
250	75.7	81.7	70.8	85.9
315	80.1	84.7	71.9	90.3
400	80.9	85.4	73.1	91
500	80.6	85.8	74.6	90.7
630	81.5	85.1	78.3	91.6
800	68	74.6	61.8	78.2
1,000	66.5	71.9	60.7	76.6
1,250	66.1	70.8	63.3	76.2
1,600	66.7	68.9	65.2	76.8
2,000	64.3	66.3	62.9	74.4
2,500	61.7	63.7	59.9	71.8
3,150	63.9	69.7	59.2	74
4,000	62.6	66.7	59.9	72.7
5,000	66.7	71.6	58.8	76.9
6,300	60.6	66.3	56.2	70.7
8,000	58.5	59.9	57.3	68.6
10,000	56.1	57.7	55.1	66.2
12,500	56.9	58.8	55.8	67.1
16,000	55.5	58.9	54.3	65.6
20,000	48.7	53.2	45.7	57.8

Test 3

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	99	102.7	94.4	109.1
16	91.1	95.6	85.4	101.2
20	96.9	101.2	92.6	107
25	98.3	102.3	90.7	108.4
31.5	89.8	96.7	77.9	99.9
40	92.8	100.1	80.9	102.8
50	89.7	96.7	74.2	99.7
63	84	90.3	77.6	94
80	84.8	91.1	73.1	94.9
100	81.7	88.1	69.7	91.8
125	74.6	79.4	68.9	84.7
160	76.5	82.8	64.8	86.6
200	72.8	79.1	65.2	82.9
250	76.3	79.4	66.3	86.3
315	68.2	74.2	58.1	78.3
400	68.6	74.2	62.9	78.6
500	67.4	70.8	62.9	77.4
630	69	73.4	62.6	79
800	73.8	79.8	61.8	83.9
1,000	72.5	76.4	66.3	82.6
1,250	65.2	70.1	61.8	75.2
1,600	66.8	70.8	64.1	76.9
2,000	65.6	68.9	64.1	75.6
2,500	61.6	64.8	59.9	71.7
3,150	58.2	59.6	57.3	68.3
4,000	57.4	60.7	55.1	67.5
5,000	57.7	61.1	56.2	67.7
6,300	60.3	63.3	57.7	70.3
8,000	59.5	61.1	58.1	69.5
10,000	55.8	57.3	55.1	65.9
12,500	57.8	59.6	55.8	67.9
16,000	57.8	60.3	56.2	67.8
20,000	48.3	52.1	46.4	58.4

Test 4

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	91.4	95.9	84.7	101.5
16	96	100.1	88.1	106.1
20	91.9	96.3	86.2	102
25	93.1	97.4	88.4	103.2
31.5	94.1	98.9	89.2	104.2
40	88	93.7	80.9	98
50	87.3	90.3	83.9	97.3
63	78.3	82.4	74.2	88.4
80	83.3	86.9	79.4	93.4
100	79.8	85.4	70.1	89.9
125	83.8	88.1	76.1	93.9
160	71.4	74.6	64.4	81.4
200	70.9	74.2	66.7	83
250	76.8	83.9	64.4	86.8
315	76.1	79.4	69.7	86.1
400	75.7	80.2	67.1	85.8
500	76.2	78.7	73.1	86.3
630	76.7	80.9	69.3	86.8
800	67.5	74.2	60.3	77.6
1,000	68.8	72.7	64.4	78.9
1,250	63.2	66.3	60.7	73.3
1,600	65.2	68.6	62.9	75.3
2,000	64.6	65.9	63.3	74.7
2,500	61	62.6	59.9	71.1
3,150	58	59.2	57.3	68.1
4,000	57.3	58.8	55.8	67.3
5,000	56.4	58.1	55.4	66.5
6,300	59.5	61.1	57.7	69.5
8,000	61.5	63.3	59.6	71.5
10,000	58.3	59.6	57.7	68.3
12,500	57.2	58.1	55.8	67.2
16,000	55	56.2	54.3	65.1
20,000	55.1	59.2	50.6	65.1

Test 5

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	90.2	94.1	83.9	100.2
16	86.9	92.9	78.7	96.9
20	86.6	90.3	81.7	96.6
25	87.9	93.3	80.6	98
31.5	79.7	84.7	73.4	89.7
40	81.4	85.4	72.3	91.4
50	85.2	90.7	67.1	95.3
63	85.2	92.6	75.7	95.2
80	81.5	85.8	74.9	91.5
100	79.6	83.9	74.6	89.7
125	75.6	79.1	68.9	85.7
160	72.7	77.6	66.3	82.7
200	75.3	80.6	66.3	85.4
250	72.5	82.1	63.3	82.5
315	75.9	80.6	66.3	85.9
400	59.8	67.9	53.6	69.8
500	70.7	77.2	58.1	80.8
630	70.4	75.3	61.8	80.5
800	62.7	66.7	57.7	72.7
1,000	64	67.8	59.6	74.1
1,250	63	67.4	57.3	73
1,600	63	64.8	61.4	73
2,000	60.7	62.9	59.2	70.7
2,500	63.1	67.8	56.6	73.1
3,150	62.1	65.6	58.1	72.1
4,000	54.8	56.2	53.9	64.9
5,000	55.5	56.9	53.9	65.5
6,300	55.6	56.9	54.7	65.6
8,000	53.9	55.1	52.8	63.9
10,000	55	56.2	53.2	65
12,500	53.9	55.4	52.8	63.9
16,000	52.9	54.7	52.1	63
20,000	52.7	58.8	47.6	62.8

Test 6

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	89.7	93.7	83.2	99.8
16	86.2	93.7	76.1	96.2
20	96.6	101.6	91.1	106.7
25	93.5	99.7	77.9	103.6
31.5	94.3	100.4	87.3	104.4
40	89.8	96.3	82.1	99.9
50	95	99.7	86.2	105.1
63	85.8	92.2	79.8	95.8
80	84.1	91.8	73.4	94.2
100	88.2	95.9	74.9	98.3
125	76.9	82.1	73.1	86.9
160	82.8	87.3	76.1	92.8
200	81.2	86.2	76.4	91.3
250	73	76.8	68.2	83
315	73.7	82.4	62.9	83.7
400	68.9	75.3	59.9	79
500	66.7	70.4	62.2	76.8
630	65.5	71.6	57.7	75.6
800	59.7	64.8	55.1	69.8
1,000	59.8	62.9	55.8	69.9
1,250	62.3	65.2	59.2	72.3
1,600	62.8	66.3	59.9	72.8
2,000	63.6	67.1	60.7	73.7
2,500	58	59.2	56.9	68.1
3,150	55.4	56.9	54.7	65.4
4,000	55.4	60.3	52.8	65.4
5,000	54.1	56.2	52.8	64.1
6,300	53.4	54.7	52.8	63.5
8,000	56.4	57.7	54.7	66.5
10,000	53.8	55.1	52.8	63.9
12,500	55.1	58.8	53.6	65.2
16,000	54.7	56.2	53.2	64.8
20,000	47	49.8	44.9	57.1

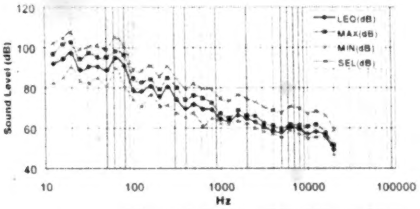
Test 7

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	90.8	94.8	84.3	100.9
16	83.9	88.8	76.4	94
20	85.4	93.2	71.9	95.5
25	86.7	91.8	80.9	96.7
31.5	82.5	86.2	78.7	92.6
40	88.7	95.9	80.2	98.8
50	79.2	82.1	76.1	89.3
63	79	84.7	71.6	89.1
80	78.9	83.9	74.2	89
100	80.2	84.7	73.8	90.2
125	82.4	89.2	74.2	92.5
160	79.2	82.4	74.2	89.3
200	71.5	75.7	67.1	81.5
250	76.6	81.3	71.6	86.6
315	73.1	78.3	68.6	83.2
400	66	71.2	60.7	76
500	59.6	66.7	54.7	69.7
630	58.9	63.3	55.4	68.9
800	61.4	65.9	55.8	71.4
1,000	68.9	76.1	57.7	79
1,250	59.5	64.1	55.4	69.6
1,600	61.4	63.3	59.2	71.5
2,000	61.2	62.9	59.6	71.3
2,500	57.1	59.6	56.2	67.2
3,150	54.9	56.2	53.9	65
4,000	54.1	55.1	52.8	64.2
5,000	52.8	54.3	52.1	62.9
6,300	55	57.3	52.8	65.1
8,000	56.1	57.7	55.1	66.2
10,000	54	55.1	53.2	64
12,500	55.1	56.6	53.9	65.2
16,000	56.3	58.1	54.7	66.4
20,000	46.9	51.7	44.9	56.9

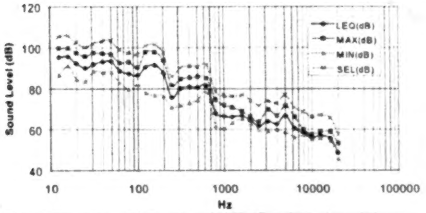
Test 8

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	87.1	90.1	80.4	97.2
16	85.1	88.8	78.7	95.2
20	85	90.3	77.2	95.1
25	78.8	84.3	73.4	88.9
31.5	80.7	88.1	67.8	90.8
40	83.3	88.1	77.9	93.4
50	75.1	80.6	70.1	85.2
63	73.6	79.8	65.9	83.7
80	70.3	74.9	64.8	80.4
100	70.2	75.3	67.8	80.3
125	71.6	77.6	65.2	81.7
160	71.7	75.7	65.9	81.8
200	65.3	67.8	63.3	75.4
250	68.4	72.7	64.8	78.5
315	62.4	66.7	57.7	72.5
400	56.4	60.7	53.2	66.5
500	60.8	67.1	53.2	70.9
630	61.4	66.3	56.6	71.4
800	61.8	67.1	56.2	71.9
1,000	56.1	58.4	53.9	66.2
1,250	55.9	59.6	53.6	66
1,600	58.1	59.6	56.9	68.2
2,000	56.9	59.6	55.8	67
2,500	56.7	60.3	54.7	66.8
3,150	54.5	56.6	52.8	64.5
4,000	53.4	54.7	51.7	63.5
5,000	53	54.3	52.4	63
6,300	53.5	54.7	50.9	63.6
8,000	54.6	56.2	53.6	64.7
10,000	54.8	56.2	53.6	64.9
12,500	54.5	56.6	52.8	64.6
16,000	54.2	55.8	52.8	64.2
20,000	46.6	49.4	44.6	56.7

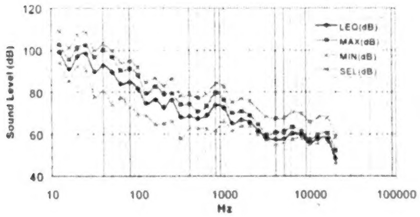
Sound Level Spectrum of 27" Slurry Pipeline (side + ambient) at North Mine, Test #1



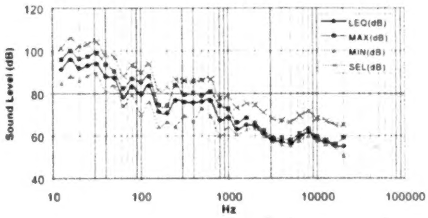
Sound Level Spectrum of 27" Slurry Pipeline (side + ambient) at North Mine, Test #2



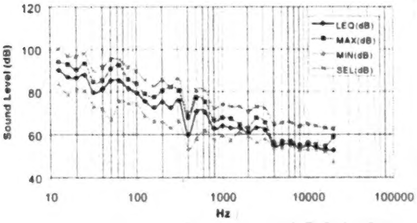
Sound Level Spectrum of 27" Slurry Pipeline (side + ambient) at North Mine, Test #3



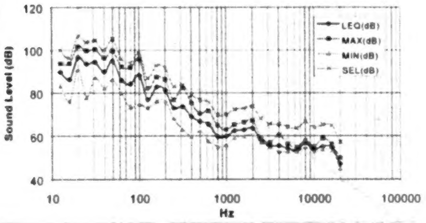
Sound Level Spectrum of 27" Slurry Pipeline (side + ambient) at North Mine, Test #4



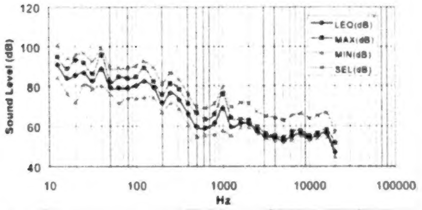
Sound Level Spectrum of 27" Slurry Pipeline (side + ambient) at North Mine, Test #5



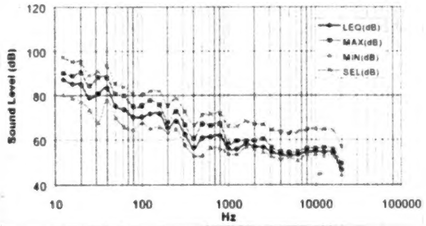
Sound Level Spectrum of 27" Slurry Pipeline (side + ambient) at North Mine, Test #6



Sound Level Spectrum of 27" Slurry Pipeline (side + ambient) at North Mine, Test #7



Sound Level Spectrum of 27" Slurry Pipeline (side + ambient) at North Mine, Test #8



Side pipeline sound level due to slurry flow
North Mine

Test 1				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	91.9	96.6	82.7	102.0
16	94.3	101.6	85.3	104.5
20	97.1	101.8	90.7	107.2
25	88.7	94.0	83.5	98.8
31.5	90.2	97.0	82.2	100.3
40	90.3	94.6	85.3	100.5
50	88.8	95.1	81.3	99.0
63	94.9	98.2	89.9	105.0
80	90.9	96.3	81.1	101.0
100	78.4	84.5	74.0	88.5
125	78.1	82.5	70.4	88.2
160	80.7	83.9	76.5	90.8
200	75.5	79.2	70.8	85.7
250	80.6	85.1	71.5	90.7
315	74.3	80.1	67.6	84.5
400	69.6	74.1	65.7	79.7
500	71.9	76.4	67.8	82.0
630	69.4	74.8	61.2	79.5
800	69.1	71.4	65.0	79.2
1000	63.8	66.1	62.3	74.1
1250	63.5	64.9	62.1	73.6
1600	66.5	68.9	63.6	76.6
2000	64.5	65.4	62.6	74.6
2500	61.8	63.3	60.1	71.9
3150	59.9	60.4	58.3	70.0
4000	58.1	59.5	57.1	68.2
5000	56.7	57.2	55.4	66.9
6300	60.4	61.6	59.1	70.5
8000	58.7	60.2	57.2	68.9
10000	55.2	56.7	53.7	65.3
12500	57.0	57.3	55.5	67.1
16000	55.6	56.8	54.8	65.7
20000	48.5	50.2	46.8	58.6

Test 2				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	95.0	99.4	85.7	105.1
16	95.2	99.3	90.8	105.3
20	91.4	96.8	82.8	101.7
25	89.2	95.1	82.2	99.3
31.5	91.5	97.0	88.2	101.6
40	93.0	97.0	88.0	103.1
50	93.4	96.7	88.1	103.5
63	88.5	92.3	82.8	98.6
80	87.0	92.6	79.3	97.1
100	86.4	90.2	82.0	96.5
125	90.5	97.8	77.4	100.7
160	91.3	97.8	76.3	101.4
200	87.4	93.7	76.3	97.6
250	75.5	81.5	70.6	85.7
315	80.0	84.7	71.8	90.2
400	80.9	85.4	73.0	91.0
500	80.5	85.6	74.5	90.6
630	81.5	85.1	78.3	91.6
800	67.9	74.6	61.6	78.1
1000	66.4	71.9	60.6	76.5
1250	66.0	70.7	63.2	76.1
1600	66.6	68.8	65.2	76.7
2000	64.2	66.0	62.8	74.3
2500	61.6	63.6	59.8	71.7
3150	63.8	69.7	59.1	73.9
4000	62.5	66.6	59.8	72.6
5000	66.7	71.6	58.7	76.9
6300	60.5	66.2	56.0	70.6
8000	57.9	59.3	56.7	68.0
10000	54.8	56.2	53.8	64.9
12500	56.6	57.9	55.6	66.8
16000	54.8	56.8	54.0	64.9
20000	46.7	50.9	45.1	55.1

Test 3				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	98.9	102.6	94.4	109.0
16	89.8	94.3	84.1	99.9
20	95.2	98.5	91.8	105.3
25	98.3	102.3	90.7	108.4
31.5	87.5	92.2	74.4	97.6
40	92.8	100.1	80.8	102.8
50	89.7	96.7	74.1	99.7
63	84.0	90.3	77.5	94.0
80	84.7	91.0	72.0	94.8
100	81.6	88.0	68.0	91.7
125	73.6	78.9	66.5	83.7
160	76.1	82.6	60.3	86.2
200	72.6	79.0	64.3	82.7
250	76.2	79.4	65.9	86.2
315	68.0	74.1	56.7	78.1
400	68.5	74.1	62.6	78.5
500	67.3	70.7	62.8	77.3
630	69.0	73.4	62.5	79.0
800	73.8	79.8	61.7	83.9
1000	72.5	76.4	66.3	82.6
1250	65.1	70.1	61.7	75.1
1600	66.8	70.8	64.1	76.9
2000	65.6	68.9	64.1	75.6
2500	61.6	64.8	59.9	71.7
3150	58.0	59.2	57.1	68.1
4000	57.1	60.5	54.7	67.2
5000	57.5	61.0	56.0	67.5
6300	60.2	63.2	57.6	70.2
8000	59.1	60.8	57.7	69.1
10000	54.7	56.3	54.1	64.8
12500	57.7	59.5	55.7	67.8
16000	57.7	60.2	56.1	67.7
20000	48.0	51.9	46.1	58.1

Test 4				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	91.3	95.6	84.6	101.4
16	96.0	100.1	88.1	106.1
20	91.9	96.3	86.2	102.0
25	93.1	97.4	88.4	103.2
31.5	94.1	98.8	89.2	104.2
40	88.0	93.7	80.9	98.0
50	87.3	90.3	83.9	97.3
63	77.8	81.4	74.0	87.9
80	83.2	86.7	79.3	93.3
100	79.5	85.3	68.4	89.6
125	83.7	88.0	75.7	93.8
160	67.2	70.1	60.9	77.2
200	70.2	73.6	65.4	82.6
250	76.7	83.9	63.2	86.7
315	76.0	79.4	69.5	86.0
400	75.6	80.1	66.8	85.7
500	76.2	78.7	73.1	86.3
630	76.7	80.9	69.3	86.8
800	67.4	74.2	60.1	77.5
1000	68.8	72.7	64.3	78.9
1250	63.0	66.2	60.5	73.1
1600	65.1	68.5	62.8	75.2
2000	64.5	65.8	63.2	74.6
2500	60.9	62.5	59.8	71.0
3150	57.8	58.9	57.1	67.9
4000	57.0	58.5	55.5	67.0
5000	56.1	57.8	55.1	66.2
6300	59.4	61.0	57.5	69.4
8000	61.2	63.1	59.3	71.2
10000	57.6	58.9	57.1	67.6
12500	57.1	57.9	55.7	67.1
16000	54.7	55.9	54.1	64.8
20000	55.0	59.1	50.5	65.0

Test 5

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	90.2	94.0	83.8	100.2
16	86.7	92.8	78.3	96.7
20	86.4	90.1	81.5	96.4
25	87.8	93.2	80.4	97.9
31.5	74.1	78.2	72.8	84.1
40	81.0	85.1	70.4	91.0
50	85.1	90.7	65.6	95.2
63	85.1	92.6	75.5	95.1
80	81.4	85.7	74.7	91.4
100	79.5	83.8	74.3	89.6
125	75.4	79.0	68.0	85.5
160	72.3	77.3	65.0	82.3
200	75.2	80.6	65.9	85.3
250	72.4	82.1	62.9	82.4
315	75.9	80.6	66.2	85.9
400	59.2	67.8	51.5	69.2
500	70.7	77.2	57.8	80.8
630	70.4	75.3	61.7	80.5
800	62.5	66.6	57.3	72.5
1000	63.9	67.7	59.4	74.0
1250	62.9	67.3	56.9	72.9
1600	62.9	64.7	61.3	72.9
2000	60.6	62.8	59.1	70.6
2500	63.1	67.8	56.5	73.1
3150	62.0	65.6	58.0	72.0
4000	54.3	55.7	53.4	64.4
5000	55.1	56.6	53.5	65.1
6300	55.4	56.7	54.4	65.3
8000	52.1	53.4	51.2	62.1
10000	53.4	54.5	51.3	63.4
12500	53.5	54.7	52.6	63.5
16000	52.4	54.2	51.6	62.5
20000	52.3	58.4	47.1	62.4

Test 6

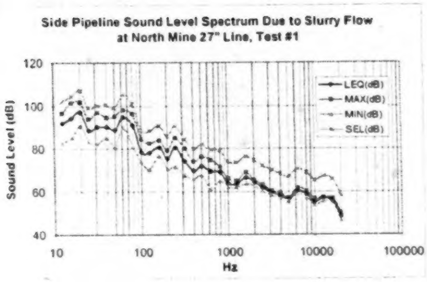
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	89.5	93.5	83.0	99.6
16	86.1	93.7	76.0	96.1
20	96.6	101.6	91.1	106.7
25	93.5	99.7	77.9	103.6
31.5	94.3	100.3	87.3	104.4
40	89.7	96.2	82.0	99.8
50	95.0	99.7	86.2	105.1
63	85.8	92.2	79.7	95.8
80	83.6	91.3	73.0	93.7
100	88.2	95.9	74.8	98.3
125	76.8	82.0	72.9	86.8
160	82.7	87.2	76.0	92.7
200	81.1	86.2	76.3	91.2
250	72.9	76.7	67.9	82.9
315	73.7	82.4	62.6	83.7
400	68.7	75.2	59.2	78.8
500	66.3	70.0	61.9	76.4
630	65.3	71.5	57.3	75.4
800	58.6	63.7	54.2	68.7
1000	59.4	62.5	55.4	69.5
1250	61.8	63.1	58.9	71.7
1600	62.1	65.7	59.6	72.1
2000	63.6	67.0	60.6	73.7
2500	57.9	59.1	56.8	68.0
3150	55.1	56.6	54.4	65.0
4000	54.9	60.1	52.2	64.9
5000	53.5	55.7	52.3	63.5
6300	53.0	54.3	52.4	63.1
8000	55.4	56.8	53.8	65.5
10000	51.5	52.8	50.7	61.7
12500	54.8	58.5	53.5	64.9
16000	54.3	55.5	52.9	64.4
20000	45.4	46.8	44.1	55.5

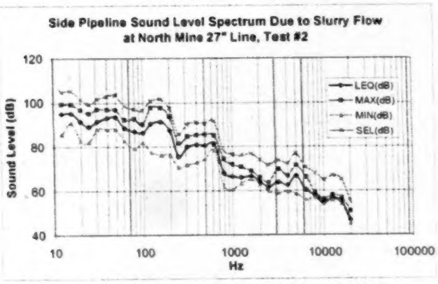
Test 7

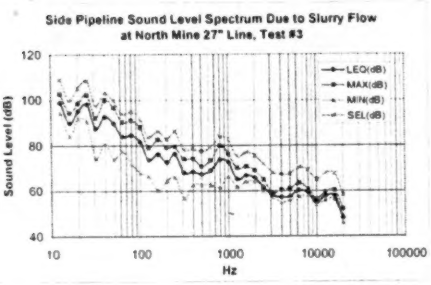
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	90.6	94.6	84.0	100.7
16	81.9	86.4	75.8	92.0
20	85.1	93.0	70.0	95.2
25	86.6	91.6	80.8	96.6
31.5	81.9	85.6	77.9	92.0
40	88.6	95.9	80.0	98.7
50	79.0	81.8	75.9	89.1
63	78.4	83.9	70.8	88.5
80	78.6	83.7	73.9	88.7
100	80.1	84.5	73.6	90.1
125	82.3	89.1	73.7	92.4
160	79.0	82.2	73.8	89.1
200	71.1	75.4	66.2	81.1
250	76.5	81.3	71.5	86.5
315	73.0	78.3	68.5	83.1
400	65.8	71.1	60.3	75.8
500	59.3	66.6	54.2	69.4
630	58.7	63.2	55.0	68.7
800	61.0	65.5	55.3	71.0
1000	68.9	76.1	57.4	79.0
1250	59.1	63.9	54.7	69.2
1600	61.3	63.1	59.1	71.4
2000	61.1	62.8	59.5	71.2
2500	57.0	59.5	56.1	67.1
3150	54.4	55.7	53.6	64.5
4000	53.4	54.4	52.2	63.5
5000	52.2	53.7	51.5	62.3
6300	54.7	57.0	52.4	64.8
8000	55.0	56.7	54.2	65.1
10000	51.7	52.8	51.1	61.6
12500	55.0	56.3	53.8	65.1
16000	56.0	57.6	54.5	66.1
20000	44.6	45.2	44.0	54.6

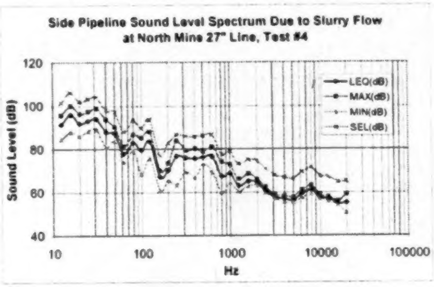
Test 8

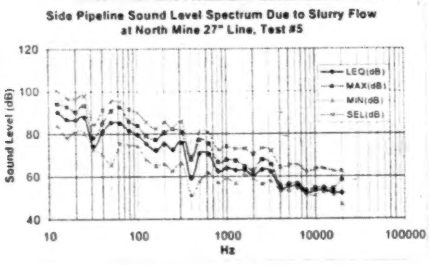
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	82.2	89.2	80.1	92.3
16	84.9	88.5	78.4	95.0
20	84.0	88.9	77.0	94.1
25	77.5	83.2	72.7	87.6
31.5	79.4	87.4	64.7	90.1
40	83.1	87.6	77.7	93.1
50	73.9	79.8	68.8	84.0
63	72.7	79.2	64.6	82.8
80	65.6	68.4	62.9	75.9
100	69.2	74.4	66.9	79.3
125	71.2	77.5	64.1	81.3
160	71.4	75.5	65.0	81.5
200	64.0	65.9	62.3	74.1
250	68.0	72.4	64.4	78.1
315	61.6	65.8	56.2	71.7
400	53.5	58.6	49.7	63.7
500	60.2	66.8	50.9	70.3
630	61.3	66.2	56.3	71.3
800	61.7	67.1	55.9	71.8
1000	55.8	58.2	53.5	65.9
1250	55.5	59.2	53.2	65.6
1600	57.9	59.4	56.7	68.0
2000	56.7	59.5	55.6	66.8
2500	56.6	60.2	54.6	66.7
3150	54.1	56.3	52.5	64.1
4000	52.7	54.0	51.1	62.8
5000	52.3	53.7	51.8	62.3
6300	53.1	54.3	50.3	63.2
8000	53.0	54.8	52.2	63.1
10000	53.2	54.7	51.9	63.3
12500	54.3	56.2	52.6	64.4
16000	53.7	54.8	52.4	63.7
20000	46.2	49.0	44.2	56.3

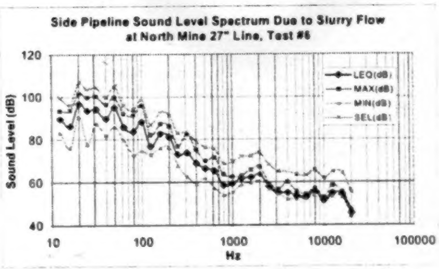

Side Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #1

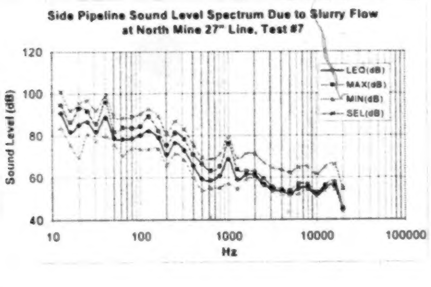

Side Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #2

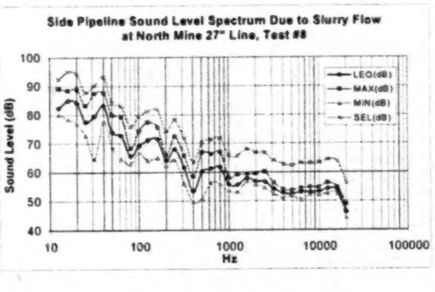

Side Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #3


Side Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #4


Side Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #5


Side Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #6


Side Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #7


Side Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #8

Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow
North Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	104.3	109.0	95.1	114.4	12.4
16	108.9	116.1	99.8	119.1	14.5
20	113.6	118.3	107.1	123.7	16.5
25	107.2	112.4	101.9	117.3	18.4
31.5	110.7	117.5	102.7	120.8	20.4
40	112.8	117.1	107.8	123.0	22.5
50	113.3	119.6	105.7	123.5	24.4
63	121.3	124.6	116.3	131.4	26.5
80	119.5	124.8	109.6	129.6	28.5
100	108.9	115.0	104.4	119.0	30.5
125	110.5	114.9	102.8	120.6	32.4
160	115.2	118.5	111.1	125.3	34.5
200	112.0	115.7	107.3	122.2	36.5
250	119.0	123.5	109.9	129.1	38.4
315	114.7	120.5	108.0	124.9	40.4
400	112.1	116.6	108.2	122.2	42.5
500	116.3	120.8	112.2	126.4	44.4
630	115.9	121.3	107.7	126.0	46.5
800	117.6	120.0	113.5	127.7	48.5
1000	114.3	116.6	112.7	124.5	50.5
1250	115.9	117.3	114.5	126.0	52.4
1600	121.0	123.4	118.2	131.1	54.5
2000	121.0	121.8	119.0	131.1	56.5
2500	120.3	121.7	118.5	130.4	58.4
3150	120.3	120.8	118.7	130.4	60.4
4000	120.6	122.0	119.6	130.7	62.5
5000	121.2	121.6	119.8	131.3	64.4
6300	126.8	128.1	125.5	136.9	66.5
8000	127.2	128.8	125.7	137.4	68.5
10000	125.7	127.2	124.2	135.8	70.5
12500	129.4	129.7	127.9	139.5	72.4
16000	130.1	131.3	129.3	140.2	74.5
20000	125.0	126.7	123.3	135.1	76.5

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	107.4	111.8	98.2	117.5	12.4
16	109.8	113.8	105.3	119.9	14.5
20	107.9	113.3	99.3	118.2	16.5
25	107.6	113.5	100.7	117.7	18.4
31.5	111.9	117.5	108.6	122.0	20.4
40	115.5	119.5	110.5	125.6	22.5
50	117.8	121.1	112.5	127.9	24.4
63	115.0	118.7	109.2	125.1	26.5
80	115.5	121.1	107.8	125.6	28.5
100	116.9	120.7	112.5	127.0	30.5
125	122.9	130.2	109.8	133.1	32.4
160	125.9	132.3	110.9	136.0	34.5
200	123.9	130.2	112.8	134.1	36.5
250	113.9	120.0	109.0	124.1	38.4
315	120.5	125.1	112.2	130.7	40.4
400	123.4	127.9	115.5	133.5	42.5
500	124.9	130.1	119.0	135.0	44.4
630	127.9	131.5	124.7	138.0	46.5
800	116.5	123.1	110.1	126.7	48.5
1000	116.9	122.3	111.0	127.0	50.5
1250	118.4	123.1	115.6	128.5	52.4
1600	121.2	123.3	119.7	131.3	54.5
2000	120.6	122.4	119.3	130.7	56.5
2500	120.0	122.0	118.3	130.1	58.4
3150	124.3	130.1	119.5	134.4	60.4
4000	125.0	129.2	122.3	135.1	62.5
5000	131.1	136.0	123.1	141.3	64.4
6300	126.9	132.6	122.5	137.0	66.5
8000	126.4	127.8	125.2	136.5	68.5
10000	125.3	126.6	124.3	135.4	70.5
12500	129.0	130.4	128.0	139.2	72.4
16000	129.4	131.4	128.5	139.5	74.5
20000	123.2	127.3	121.6	131.5	76.5

Test 3

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	111.3	115.0	106.8	121.4	12.4
16	104.4	108.9	98.7	114.5	14.5
20	111.6	115.0	108.3	121.7	16.5
25	116.7	120.7	109.1	126.8	18.4
31.5	108.0	112.6	94.9	118.1	20.4
40	115.3	122.6	103.3	125.3	22.5
50	114.1	121.1	98.5	124.1	24.4
63	110.4	116.7	104.0	120.4	26.5
80	113.2	119.6	100.5	123.3	28.5
100	112.0	118.5	98.5	122.1	30.5
125	106.0	111.3	98.9	116.1	32.4
160	110.7	117.2	94.8	120.8	34.5
200	109.1	115.5	100.7	119.2	36.5
250	114.7	117.8	104.3	124.7	38.4
315	108.4	114.6	97.2	118.5	40.4
400	111.0	116.6	105.1	121.0	42.5
500	111.8	115.2	107.2	121.8	44.4
630	115.4	119.8	109.0	125.4	46.5
800	122.3	128.3	110.2	132.4	48.5
1000	123.0	126.9	116.7	133.1	50.5
1250	117.5	122.5	114.1	127.5	52.4
1600	121.3	125.3	118.6	131.4	54.5
2000	122.1	125.4	120.6	132.1	56.5
2500	120.0	123.2	118.3	130.1	58.4
3150	118.4	119.7	117.6	128.5	60.4
4000	119.6	123.0	117.2	129.7	62.5
5000	121.9	125.4	120.4	131.9	64.4
6300	126.7	129.7	124.0	136.7	66.5
8000	127.7	129.3	126.3	137.6	68.5
10000	125.2	126.7	124.5	135.3	70.5
12500	130.1	131.9	128.1	140.2	72.4
16000	132.2	134.7	130.6	142.2	74.5
20000	124.5	128.4	122.6	134.6	76.5

Test 4

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	103.7	108.0	97.0	113.8	12.4
16	110.5	114.6	102.6	120.6	14.5
20	108.4	112.8	102.7	118.5	16.5
25	111.5	115.8	106.8	121.6	18.4
31.5	114.5	119.3	109.6	124.6	20.4
40	110.5	116.2	103.4	120.5	22.5
50	111.7	114.7	108.3	121.7	24.4
63	104.3	107.8	100.5	114.4	26.5
80	111.7	115.3	107.8	121.8	28.5
100	109.9	115.7	98.9	120.0	30.5
125	116.1	120.4	108.1	126.2	32.4
160	101.8	104.6	95.5	111.8	34.5
200	106.7	110.0	101.9	119.0	36.5
250	115.1	122.3	101.7	125.1	38.4
315	116.5	119.8	110.0	126.5	40.4
400	118.1	122.6	109.3	128.2	42.5
500	120.6	123.1	117.5	130.7	44.4
630	123.1	127.3	115.7	133.2	46.5
800	116.0	122.7	108.6	126.1	48.5
1000	119.2	123.1	114.8	129.3	50.5
1250	115.4	118.6	112.9	125.5	52.4
1600	119.6	123.1	117.3	129.7	54.5
2000	121.0	122.3	119.7	131.1	56.5
2500	119.3	120.9	118.2	129.4	58.4
3150	118.2	119.3	117.5	128.3	60.4
4000	119.5	121.0	118.0	129.5	62.5
5000	120.5	122.2	119.6	130.6	64.4
6300	125.8	127.4	124.0	135.8	66.5
8000	129.8	131.6	127.8	139.7	68.5
10000	128.1	129.4	127.5	138.1	70.5
12500	129.5	130.3	128.1	139.5	72.4
16000	129.3	130.5	128.6	139.4	74.5
20000	131.5	135.6	126.9	141.5	76.5

Test 5

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	102.6	106.4	96.2	112.6	12.4
16	101.3	107.3	92.8	111.3	14.5
20	102.9	106.6	98.0	112.9	16.5
25	106.2	111.6	98.8	116.3	18.4
31.5	94.5	98.6	93.2	104.5	20.4
40	103.5	107.6	92.9	113.5	22.5
50	109.6	115.1	90.0	119.7	24.4
63	111.6	119.0	101.9	121.6	26.5
80	109.9	114.2	103.2	119.9	28.5
100	109.9	114.3	104.8	120.0	30.5
125	107.8	111.4	100.5	117.9	32.4
160	106.8	111.8	99.6	116.8	34.5
200	111.7	117.0	102.4	121.8	36.5
250	110.8	120.5	101.3	120.8	38.4
315	116.3	121.0	106.6	126.3	40.4
400	101.7	110.3	94.0	111.7	42.5
500	115.1	121.6	102.2	125.2	44.4
630	116.8	121.7	108.1	126.9	46.5
800	111.1	115.1	105.9	121.1	48.5
1000	114.4	118.2	109.9	124.5	50.5
1250	115.3	119.7	109.3	125.3	52.4
1600	117.4	119.2	115.8	127.4	54.5
2000	117.1	119.3	115.5	127.1	56.5
2500	121.5	126.2	114.9	131.5	58.4
3150	122.5	126.0	118.4	132.5	60.4
4000	116.8	118.2	115.9	126.9	62.5
5000	119.6	121.0	117.9	129.6	64.4
6300	121.8	123.1	120.9	131.8	66.5
8000	120.6	121.9	119.8	130.6	68.5
10000	123.9	125.0	121.8	133.9	70.5
12500	126.0	127.1	125.0	136.0	72.4
16000	126.9	128.8	126.1	137.0	74.5
20000	128.7	134.9	123.6	138.8	76.5

Test 6

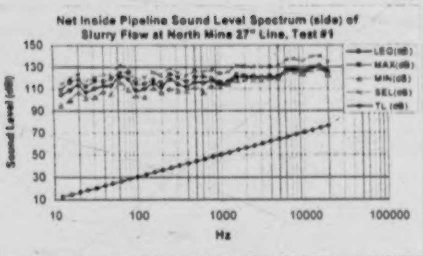
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	101.9	105.9	95.4	112.0	12.4
16	100.7	108.2	90.5	110.7	14.5
20	113.1	118.1	107.6	123.2	16.5
25	111.9	118.1	96.3	122.0	18.4
31.5	114.7	120.8	107.7	124.8	20.4
40	112.2	118.7	104.5	122.3	22.5
50	119.4	124.1	110.6	129.5	24.4
63	112.2	118.6	106.2	122.2	26.5
80	112.2	119.8	101.5	122.3	28.5
100	118.7	126.4	105.3	128.8	30.5
125	109.2	114.4	105.3	119.2	32.4
160	117.3	121.8	110.5	127.3	34.5
200	117.6	122.7	112.8	127.7	36.5
250	111.3	115.1	106.3	121.3	38.4
315	114.1	122.8	103.0	124.1	40.4
400	111.2	117.7	101.7	121.3	42.5
500	110.8	114.4	106.3	120.9	44.4
630	111.8	117.9	103.8	121.9	46.5
800	107.2	112.2	102.7	117.3	48.5
1000	109.9	112.9	105.8	120.0	50.5
1250	114.2	115.5	111.3	124.1	52.4
1600	116.7	120.2	114.1	126.7	54.5
2000	120.0	123.5	117.1	130.1	56.5
2500	116.3	117.5	115.2	126.4	58.4
3150	115.5	117.0	114.9	125.5	60.4
4000	117.4	122.6	114.7	127.4	62.5
5000	118.0	120.1	116.7	128.0	64.4
6300	119.4	120.7	118.9	129.5	66.5
8000	124.0	125.3	122.3	134.1	68.5
10000	122.0	123.2	121.1	132.2	70.5
12500	127.2	130.9	125.9	137.3	72.4
16000	128.9	130.1	127.4	139.0	74.5
20000	121.9	123.3	120.6	132.0	76.5

Test 7

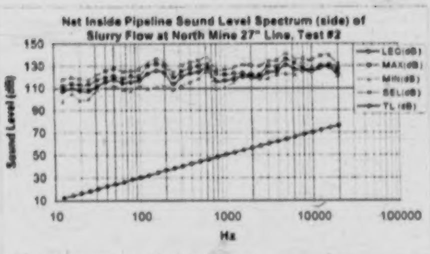
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	103.0	107.0	96.4	113.1	12.4
16	96.4	100.9	90.4	106.5	14.5
20	101.6	109.4	86.5	111.7	16.5
25	105.0	110.0	99.2	115.0	18.4
31.5	102.3	106.0	98.4	112.4	20.4
40	111.1	118.4	102.5	121.2	22.5
50	103.4	106.2	100.3	113.5	24.4
63	104.8	110.4	97.3	114.9	26.5
80	107.2	112.2	102.4	117.3	28.5
100	110.5	115.0	104.0	120.5	30.5
125	114.7	121.5	106.1	124.8	32.4
160	113.5	116.8	108.3	123.6	34.5
200	107.5	111.9	102.7	117.5	36.5
250	115.0	119.7	109.9	125.0	38.4
315	113.5	118.7	108.9	123.6	40.4
400	108.3	113.6	102.8	118.3	42.5
500	103.8	111.1	98.6	113.9	44.4
630	105.1	109.6	101.5	115.1	46.5
800	109.5	114.0	103.8	119.5	48.5
1000	119.3	126.6	107.9	129.4	50.5
1250	111.5	116.3	107.1	121.6	52.4
1600	115.8	117.7	113.6	125.9	54.5
2000	117.6	119.3	116.0	127.7	56.5
2500	115.4	117.9	114.6	125.5	58.4
3150	114.9	116.1	114.0	125.0	60.4
4000	115.9	116.9	114.7	126.0	62.5
5000	116.6	118.2	115.9	126.7	64.4
6300	121.2	123.5	118.9	131.3	66.5
8000	123.5	125.2	122.7	133.6	68.5
10000	122.1	123.2	121.5	132.0	70.5
12500	127.4	128.7	126.2	137.5	72.4
16000	130.5	132.2	129.0	140.6	74.5
20000	121.1	121.7	120.5	131.0	76.5

Test 8

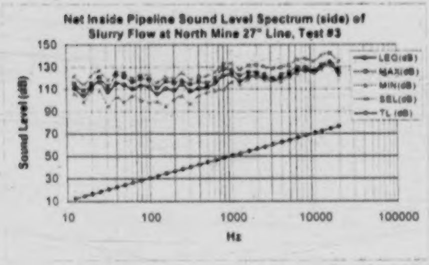
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	94.6	101.6	92.5	104.7	12.4
16	99.5	103.0	93.0	109.6	14.5
20	100.5	105.4	93.5	110.6	16.5
25	96.0	101.6	91.1	106.1	18.4
31.5	99.8	107.8	85.1	110.5	20.4
40	105.6	110.1	100.2	115.6	22.5
50	98.3	104.3	93.3	108.4	24.4
63	99.2	105.7	91.1	109.3	26.5
80	94.1	96.9	91.4	104.4	28.5
100	99.6	104.8	97.3	109.7	30.5
125	103.6	109.9	96.5	113.7	32.4
160	106.0	110.1	99.5	116.1	34.5
200	100.5	102.4	98.7	110.6	36.5
250	106.5	110.8	102.8	116.6	38.4
315	102.1	106.2	96.6	112.2	40.4
400	96.0	101.1	92.2	106.2	42.5
500	104.7	111.2	95.3	114.8	44.4
630	107.7	112.7	102.7	117.7	46.5
800	110.2	115.6	104.5	120.3	48.5
1000	106.3	108.6	104.0	116.4	50.5
1250	107.9	111.6	105.6	118.0	52.4
1600	112.5	113.9	111.3	122.6	54.5
2000	113.2	116.0	112.1	123.3	56.5
2500	115.0	118.7	113.0	125.1	58.4
3150	114.5	116.7	112.9	124.5	60.4
4000	115.2	116.5	113.6	125.3	62.5
5000	116.8	118.1	116.2	126.8	64.4
6300	119.5	120.7	116.7	129.6	66.5
8000	121.5	123.3	120.8	131.6	68.5
10000	123.7	125.1	122.4	133.8	70.5
12500	126.7	128.6	125.0	136.8	72.4
16000	128.3	129.3	126.9	138.3	74.5
20000	122.7	125.4	120.6	132.8	76.5



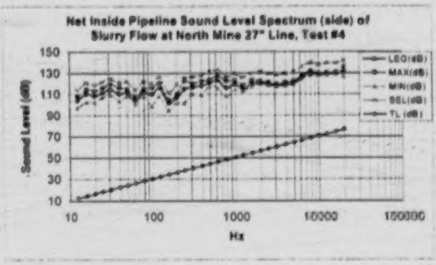
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #1



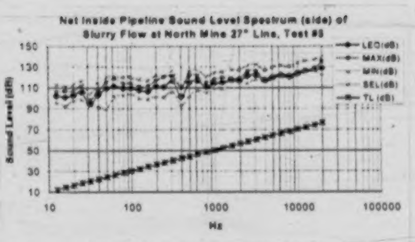
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #2



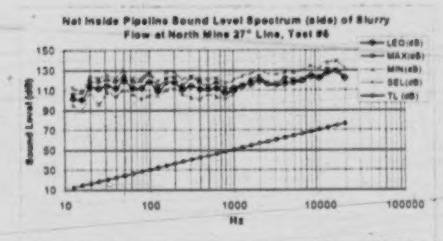
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #3



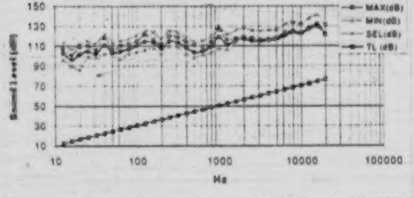
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #4



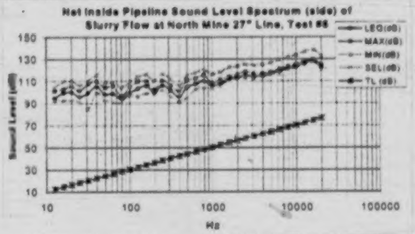
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #5



Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #6



Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #7



Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #8

Net inside pipeline sound level spectrum (side)
North Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	104.3	109.0	95.1	114.4
16	108.9	116.1	99.8	119.1
20	113.6	118.3	107.1	123.7
25	107.2	112.4	101.9	117.3
31.5	110.7	117.5	102.7	120.8
40	112.8	117.1	107.8	123.0
50	113.3	119.6	105.7	123.5
63	121.3	124.6	116.3	131.4
80	119.5	124.8	109.6	129.6
100	108.9	115.0	104.4	119.0
125	110.5	114.9	102.8	120.6
160	115.2	118.5	111.1	125.3
200	112.0	115.7	107.3	122.2
250	119.0	123.5	109.9	129.1
315	114.7	120.5	108.0	124.9
400	112.1	116.6	108.2	122.2
500	116.3	120.8	112.2	125.4
630	115.9	121.3	107.7	126.0
800	117.6	120.0	113.5	127.7
1000	114.3	116.5	112.7	124.5
1250	115.9	117.3	114.5	126.0
1600	121.0	123.4	118.2	131.1
2000	121.0	121.8	119.0	131.1
2500	120.3	121.7	118.5	130.4
3150	120.3	120.8	118.7	130.4
4000	120.6	122.0	119.6	130.7
5000	121.2	121.6	119.8	131.3
6300	126.8	128.1	125.5	136.9
8000	127.2	128.8	125.7	137.4
10000	125.7	127.2	124.2	135.8
12500	129.4	129.7	127.9	139.5
16000	130.1	131.3	129.3	140.2
20000	125.0	126.7	123.3	135.1

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	107.4	111.8	98.2	117.5
16	109.8	113.8	105.3	119.9
20	107.9	113.3	99.3	118.2
25	107.6	113.5	100.7	117.7
31.5	111.9	117.5	108.6	122.0
40	115.5	119.5	110.5	125.6
50	117.8	121.1	112.5	127.9
63	115.0	118.7	109.2	125.1
80	115.5	121.1	107.8	125.6
100	116.9	120.7	112.5	127.0
125	122.9	130.2	109.8	133.1
160	125.9	132.3	110.9	136.0
200	123.9	130.2	112.8	134.1
250	113.9	120.0	109.0	124.1
315	120.5	125.1	112.2	130.7
400	123.4	127.9	115.5	133.5
500	124.9	130.1	119.0	135.0
630	127.9	131.5	124.7	138.0
800	116.5	123.1	110.1	125.7
1000	116.9	122.3	111.0	127.0
1250	118.4	123.1	115.6	128.5
1600	121.2	123.3	119.7	131.3
2000	120.6	122.4	119.3	130.7
2500	120.0	122.0	118.3	130.1
3150	124.3	130.1	119.5	134.4
4000	125.0	129.2	122.3	135.1
5000	131.1	136.0	123.1	141.3
6300	126.9	132.6	122.5	137.0
8000	126.4	127.8	125.2	136.5
10000	125.3	126.6	124.3	135.4
12500	129.0	130.4	128.0	139.2
16000	129.4	131.4	128.5	139.5
20000	123.2	127.3	121.6	131.5

Test 3

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	111.3	115.0	106.8	121.4
16	104.4	108.9	98.7	114.5
20	111.6	115.0	108.3	121.7
25	116.7	120.7	109.1	126.8
31.5	108.0	112.6	94.9	118.1
40	115.3	122.6	103.3	125.3
50	114.1	121.1	98.5	124.1
63	110.4	116.7	104.0	120.4
80	113.2	119.6	100.5	123.3
100	112.0	118.5	98.5	122.1
125	106.0	111.3	98.9	116.1
160	110.7	117.2	94.8	120.8
200	109.1	115.5	100.7	119.2
250	114.7	117.8	104.3	124.7
315	108.4	114.6	97.2	118.5
400	111.0	116.6	105.1	121.0
500	111.8	115.2	107.2	121.8
630	115.4	119.8	109.0	125.4
800	122.3	128.3	110.2	132.4
1000	123.0	126.9	116.7	133.1
1250	117.5	122.5	114.1	127.5
1600	121.3	125.3	118.6	131.4
2000	122.1	125.4	120.6	132.1
2500	120.0	123.2	118.3	130.1
3150	118.4	119.7	117.6	128.5
4000	119.6	123.0	117.2	129.7
5000	121.9	125.4	120.4	131.9
6300	126.7	129.7	124.0	136.7
8000	127.7	129.3	126.3	137.6
10000	125.2	126.7	124.5	135.3
12500	130.1	131.9	128.1	140.2
16000	132.2	134.7	130.6	142.2
20000	124.5	128.4	122.6	134.6

Test 4

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	103.7	108.0	97.0	113.8
16	110.5	114.6	102.6	120.6
20	108.4	112.8	102.7	118.5
25	111.5	115.8	106.8	121.6
31.5	114.5	119.3	109.6	124.6
40	110.5	116.2	103.4	120.5
50	111.7	114.7	108.3	121.7
63	104.3	107.8	100.5	114.4
80	111.7	115.3	107.8	121.8
100	109.9	115.7	98.9	120.0
125	116.1	120.4	108.1	126.2
160	101.8	104.6	95.5	111.8
200	106.7	110.0	101.9	119.0
250	115.1	122.3	101.7	125.1
315	116.5	119.8	110.0	126.5
400	118.1	122.6	109.3	128.2
500	120.6	123.1	117.5	130.7
630	123.1	127.3	115.7	133.2
800	116.0	122.7	108.6	126.1
1000	119.2	123.1	114.8	129.3
1250	115.4	118.6	112.9	125.5
1600	119.6	123.1	117.3	129.7
2000	121.0	122.3	119.7	131.1
2500	119.3	120.9	118.2	129.4
3150	118.2	119.3	117.5	128.3
4000	119.5	121.0	118.0	129.5
5000	120.5	122.2	119.6	130.6
6300	125.8	127.4	124.0	135.8
8000	129.8	131.6	127.8	139.7
10000	128.1	129.4	127.5	138.1
12500	129.5	130.3	128.1	139.5
16000	129.3	130.5	128.6	139.4
20000	131.5	135.6	126.9	141.5

Test 5

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	102.6	106.4	96.2	112.6
16	101.3	107.3	92.8	111.3
20	102.9	106.6	98.0	112.9
25	106.2	111.6	98.8	116.3
31.5	94.5	98.6	93.2	104.5
40	103.5	107.6	92.9	113.5
50	109.6	115.1	90.0	119.7
63	111.6	119.0	101.9	121.6
80	109.9	114.2	103.2	119.9
100	109.9	114.3	104.8	120.0
125	107.8	111.4	100.5	117.9
160	106.8	111.8	99.6	116.8
200	111.7	117.0	102.4	121.8
250	110.8	120.5	101.3	120.8
315	116.3	121.0	106.6	126.3
400	101.7	110.3	94.0	111.7
500	115.1	121.6	102.2	125.2
630	116.8	121.7	108.1	126.9
800	111.1	115.1	105.9	121.1
1000	114.4	118.2	109.9	124.5
1250	115.3	119.7	109.3	125.3
1600	117.4	119.2	115.8	127.4
2000	117.1	119.3	115.5	127.1
2500	121.5	126.2	114.9	131.5
3150	122.5	126.0	118.4	132.5
4000	116.8	118.2	115.9	126.9
5000	119.6	121.0	117.9	129.6
6300	121.8	123.1	120.9	131.8
8000	120.6	121.9	119.8	130.6
10000	123.9	125.0	121.8	133.9
12500	126.0	127.1	125.0	136.0
16000	126.9	128.8	126.1	137.0
20000	128.7	134.9	123.6	138.6

Test 6

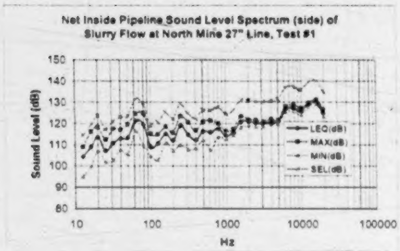
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	101.9	105.9	95.4	112.0
16	100.7	108.2	90.5	110.7
20	113.1	118.1	107.6	123.2
25	111.9	118.1	95.3	122.0
31.5	114.7	120.8	107.7	124.8
40	112.2	118.7	104.5	122.3
50	119.4	124.1	110.6	129.5
63	112.2	118.6	106.2	122.2
80	112.2	119.8	101.5	122.3
100	118.7	126.4	105.3	128.8
125	109.2	114.4	105.3	119.2
160	117.3	121.8	110.5	127.3
200	117.6	122.7	112.8	127.7
250	111.3	115.1	106.3	121.3
315	114.1	122.8	103.0	124.1
400	111.2	117.7	101.7	121.3
500	110.8	114.4	106.3	120.9
630	111.8	117.9	103.8	121.9
800	107.2	112.2	102.7	117.3
1000	109.9	112.9	105.8	120.0
1250	114.2	115.5	111.3	124.1
1600	116.7	120.2	114.1	126.7
2000	120.0	123.5	117.1	130.1
2500	116.3	117.5	115.2	126.4
3150	115.5	117.0	114.9	125.5
4000	117.4	122.6	114.7	127.4
5000	118.0	120.1	116.7	128.0
6300	119.4	120.7	118.9	129.5
8000	124.0	125.3	122.3	134.1
10000	122.0	123.2	121.1	132.2
12500	127.2	130.9	125.9	137.3
16000	128.9	130.1	127.4	139.0
20000	121.9	123.3	120.6	132.0

Test 7

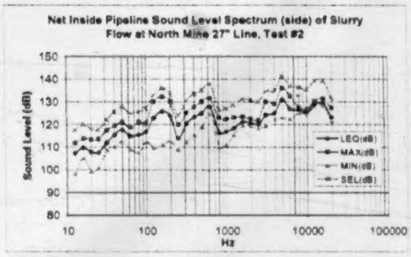
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	103.0	107.0	96.4	113.1
16	96.4	100.9	90.4	106.5
20	101.6	109.4	86.5	111.7
25	105.0	110.0	99.2	115.0
31.5	102.3	106.0	98.4	112.4
40	111.1	118.4	102.5	121.2
50	103.4	108.2	100.3	113.5
63	104.8	110.4	97.3	114.9
80	107.2	112.2	102.4	117.3
100	110.5	115.0	104.0	120.5
125	114.7	121.5	106.1	124.8
160	113.5	116.8	108.3	123.6
200	107.5	111.9	102.7	117.5
250	115.0	119.7	109.9	125.0
315	113.5	118.7	108.9	123.6
400	108.3	113.6	102.8	118.3
500	103.8	111.1	98.6	113.9
630	105.1	109.6	101.5	115.1
800	109.5	114.0	103.8	119.5
1000	119.3	126.6	107.9	129.4
1250	111.5	116.3	107.1	121.6
1600	115.8	117.7	113.6	125.9
2000	117.6	119.3	116.0	127.7
2500	115.4	117.9	114.6	125.5
3150	114.9	116.1	114.0	125.0
4000	115.9	116.9	114.7	126.0
5000	116.6	118.2	115.9	126.7
6300	121.2	123.5	118.9	131.3
8000	123.5	125.2	122.7	133.6
10000	122.1	123.2	121.5	132.0
12500	127.4	128.7	126.2	137.5
16000	130.5	132.2	129.0	140.6
20000	121.1	121.7	120.5	131.0

Test 8

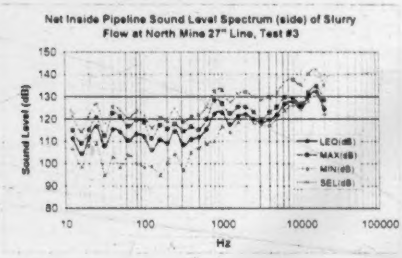
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	94.6	101.6	92.5	104.7
16	99.5	103.0	93.0	109.6
20	100.5	105.4	93.5	110.6
25	96.0	101.6	91.1	106.1
31.5	99.8	107.8	85.1	110.5
40	105.6	110.1	100.2	115.6
50	98.3	104.3	93.3	108.4
63	99.2	105.7	91.1	109.3
80	94.1	96.9	91.4	104.4
100	99.6	104.8	97.3	109.7
125	103.6	109.9	96.5	113.7
160	106.0	110.1	99.5	116.1
200	100.5	102.4	98.7	110.6
250	106.5	110.8	102.8	116.6
315	102.1	106.2	96.6	112.2
400	96.0	101.1	92.2	106.2
500	104.7	111.2	95.3	114.8
630	107.7	112.7	102.7	117.7
800	110.2	115.6	104.5	120.3
1000	106.3	108.6	104.0	116.4
1250	107.9	111.6	105.6	118.0
1600	112.5	113.9	111.3	122.6
2000	113.2	116.0	112.1	123.3
2500	115.0	118.7	113.0	125.1
3150	114.5	116.7	112.9	124.5
4000	115.2	116.5	113.6	125.3
5000	116.8	118.1	116.2	126.8
6300	119.5	120.7	116.7	129.6
8000	121.5	123.3	120.8	131.6
10000	123.7	125.1	122.4	133.8
12500	126.7	128.6	125.0	136.8
16000	128.3	129.3	126.9	138.3
20000	122.7	125.4	120.6	132.8



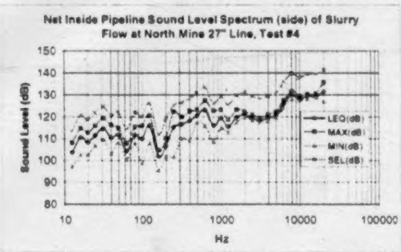
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #1



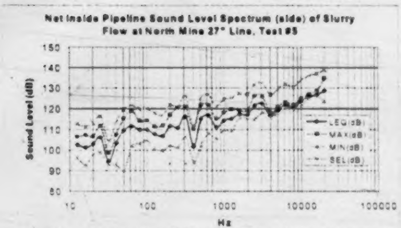
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #2



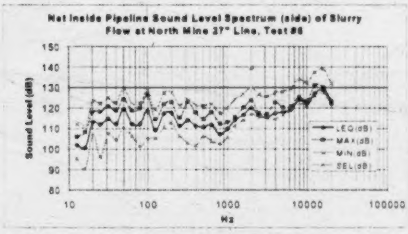
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #3



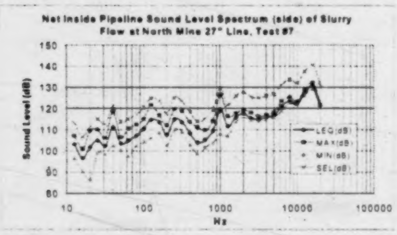
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #4



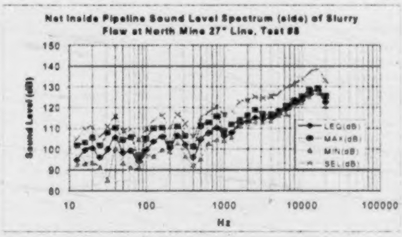
Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #5



Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #6



Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #7

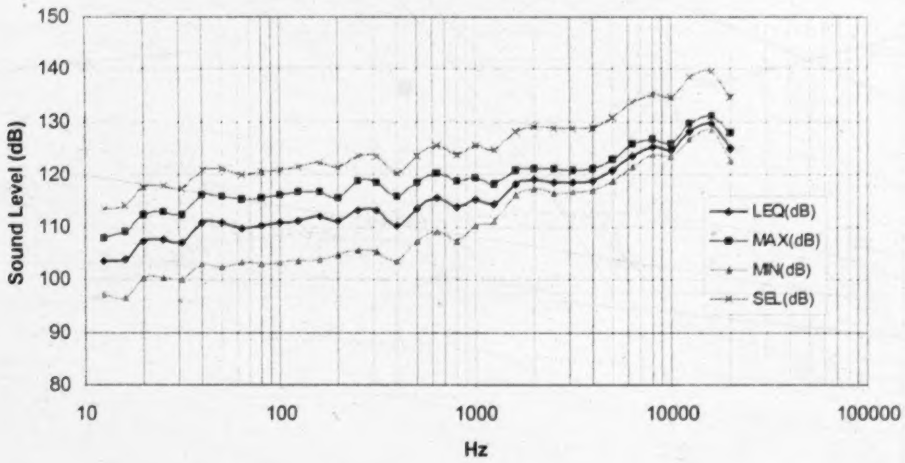


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line, Test #8

Average Net Inside Pipeline Sound Level Spectrum
side of slurry flow, North Mine

Average FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	103.6	108.1	97.2	113.7
16	103.9	109.1	96.6	114.0
20	107.5	112.4	100.4	117.6
25	107.8	113.0	100.5	117.8
31.5	107.1	112.5	100.0	117.2
40	110.8	116.3	103.1	120.9
50	111.0	115.8	102.4	121.1
63	109.9	115.2	103.3	119.9
80	110.4	115.5	103.0	120.5
100	110.8	116.3	103.2	120.9
125	111.3	116.7	103.5	121.4
160	112.1	116.6	103.8	122.2
200	111.1	115.7	104.9	121.5
250	113.3	118.7	105.6	123.3
315	113.3	118.6	105.3	123.3
400	110.2	115.8	103.6	120.3
500	113.5	118.4	107.3	123.6
630	115.5	120.2	109.2	125.5
800	113.8	118.9	107.4	123.9
1000	115.4	119.4	110.3	125.5
1250	114.5	118.1	111.3	124.6
1600	118.2	120.8	116.1	128.3
2000	119.1	121.2	117.4	129.1
2500	118.5	121.0	116.4	128.6
3150	118.6	120.7	116.7	128.6
4000	118.8	121.2	117.0	128.8
5000	120.7	122.8	118.7	130.8
6300	123.5	125.7	121.4	133.6
8000	125.1	126.7	123.8	135.2
10000	124.5	125.8	123.4	134.5
12500	128.1	129.7	126.8	138.2
16000	129.4	131.0	128.3	139.5
20000	124.8	127.9	122.5	134.7
Overall	135.4	137.7	133.7	145.5

Average Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at North Mine 27" Line



7.4.3: Pipeline Top

Sound Level Spectrum of 27" Slurry Pipeline (top + ambient)
North Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	101.6	106.8	93.7	111.8
16	93.2	97.1	89.6	103.3
20	94.4	98.9	89.6	104.5
25	96.9	104.6	88.4	107
31.5	96.1	100.8	86.6	106.3
40	89.1	92.9	83.2	99.2
50	99.1	103.4	92.6	109.3
63	90	94.1	83.9	100.1
80	87.4	92.2	78.3	97.5
100	90.4	96.7	80.6	100.5
125	78.6	83.9	72.3	88.8
160	87.5	93.7	73.1	97.6
200	85.8	90.7	77.6	95.9
250	77.5	85.1	68.9	87.6
315	73.2	78.7	62.9	83.3
400	76.9	82.4	63.3	87.1
500	73.5	80.6	61.8	83.6
630	75.3	80.2	67.1	85.4
800	73.6	79.1	63.7	83.7
1,000	66	73.1	59.9	76.1
1,250	67	73.4	61.4	77.1
1,600	67	71.2	62.9	77.2
2,000	64.5	69.3	60.7	74.6
2,500	59.3	66.1	55.4	69.5
3,150	60.6	68.2	56.2	70.7
4,000	64.2	72.7	57.3	74.3
5,000	57.8	61.1	55.8	67.9
6,300	58.1	61.8	56.2	68.2
8,000	57.1	59.4	55.3	67.2
10,000	56.1	60.4	54.3	66.2
12,500	57.5	61.8	55.1	67.7
16,000	60.4	65.2	56.2	70.5
20,000	51.8	53.9	50.2	61.9

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	93.2	97.8	84.3	103.3
16	90.9	95.2	83.9	101
20	92.5	97.4	81.1	102.6
25	90.9	96.7	79.8	101
31.5	84.6	90.1	81.1	94.7
40	89	93.7	81.7	99.1
50	86.5	92.6	81.3	96.6
63	89.3	95.6	82.1	99.4
80	88.4	92.9	82.4	98.5
100	80.7	83.6	75.7	90.8
125	80.4	88.1	73.8	90.5
160	77.1	81.7	72.7	87.2
200	65.6	69.7	63.1	75.7
250	66.2	70.8	58.8	76.3
315	67.9	70.8	64.8	78
400	65.4	71.2	59.9	75.5
500	65.1	72.4	58.2	75
630	67	74.2	60.3	77.1
800	69.3	75.3	61.4	79.4
1,000	68.1	73.8	61.8	78.2
1,250	62.3	66.3	59.2	72.4
1,600	61.2	67.1	57.3	71.3
2,000	64	69.3	58.1	74.1
2,500	62.8	67.8	57.3	72.9
3,150	54.8	56.9	53.2	64.9
4,000	52.6	54.3	51.3	62.7
5,000	52	53.6	50.9	62.1
6,300	54.3	59.2	49.8	64.4
8,000	53.9	56.1	53.2	64
10,000	53	55.1	51.7	63.1
12,500	51.7	55.6	49.8	61.8
16,000	62.1	70.4	53.6	72.2
20,000	45.4	51.6	40.8	56.5

Test 3

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	94.7	99.3	91.1	104.7
16	90.5	93.3	86.6	100.6
20	92.7	98.7	84.9	102.8
25	93.5	99.7	85.1	103.6
31.5	94.9	99.7	84.3	104.9
40	91.9	97.4	83.6	102
50	95	98.9	87.3	105
63	88.5	92.6	82.4	98.6
80	84.6	88.8	79.1	94.6
100	80.6	84.3	74.2	90.6
125	77.3	80.9	72.3	87.4
160	71.4	76.1	65.6	81.5
200	69.1	74.9	63.3	79.1
250	68	72.3	63.7	78.1
315	71	79.1	60.3	81.1
400	65.9	70.4	61.4	76
500	65.7	72.3	59.2	75.8
630	63.5	68.9	58.1	73.6
800	69.3	75.7	61.4	79.3
1,000	64.8	68.6	60.3	74.8
1,250	61.5	63.7	59.6	71.6
1,600	63.1	67.1	61.1	73.2
2,000	59.9	61.8	58.8	70
2,500	58.6	61.1	57.3	68.6
3,150	56.4	57.7	55.4	66.5
4,000	55.2	56.6	53.9	65.2
5,000	54.1	55.8	52.8	64.1
6,300	54.8	55.8	53.2	64.9
8,000	54.6	55.8	53.2	64.7
10,000	56.1	57.7	54.7	66.2
12,500	54.5	55.4	53.2	64.5
16,000	54.6	55.8	53.2	64.6
20,000	46.6	49.8	44.9	56.7

Test 4

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	98.7	103.1	90.3	108.8
16	98.3	104.2	93.7	108.4
20	95.6	101.2	90.3	105.7
25	91.6	96.3	88.1	101.7
31.5	88.4	93.3	81.7	98.5
40	92.4	98.9	79.4	102.5
50	96.1	100.1	92.2	106.1
63	93	97.4	88.1	103
80	90.9	94.8	85.8	101
100	84.9	90.3	79.1	94.9
125	87.6	91.1	82.4	97.7
160	84	92.6	75.7	94
200	82.8	89.2	73.1	92.8
250	76.4	80.2	69.3	86.4
315	73.8	77.9	69.7	83.9
400	69.9	76.4	60.7	80
500	67	73.4	59.6	77
630	62.1	67.4	55.1	72.2
800	63.1	68.6	58.8	73.1
1,000	60.2	64.1	57.3	70.3
1,250	61.4	64.1	59.2	71.4
1,600	57.8	59.6	56.9	67.9
2,000	57.6	60.7	56.5	67.7
2,500	57	59.6	55.8	67
3,150	55.5	56.9	54.3	65.6
4,000	54.9	56.2	53.2	64.9
5,000	54.9	56.2	53.9	64.9
6,300	55	56.6	53.9	65.1
8,000	55.4	56.9	54.3	65.4
10,000	55.3	56.9	54.3	65.4
12,500	54.8	57.3	53.6	64.8
16,000	55.4	57.7	53.6	65.5
20,000	49.9	53.2	45.3	60

Test 5

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	91.6	96.7	85.4	101.7
16	90.8	95.6	84.3	100.9
20	90.1	95.9	83.6	100.2
25	87.9	91.8	82.1	98
31.5	89.3	94.8	83.9	99.4
40	91.6	98.6	84.7	101.6
50	89	92.6	86.6	99.1
63	82.5	91.1	77.9	92.5
80	92.2	96.7	86.9	102.2
100	83.7	88.4	79.4	93.7
125	82.4	89.2	69.7	92.5
160	73	81.3	65.2	83
200	77	81.3	72.3	87.1
250	74.3	79.8	67.1	84.4
315	63.3	70.4	57.3	73.4
400	69.5	74.2	62.9	79.5
500	72.8	77.2	67.8	82.9
630	74.4	77.6	70.1	84.5
800	71.4	74.9	67.8	81.4
1,000	69	73.8	63.3	79
1,250	58	61.8	55.4	68
1,600	63.6	70.8	55.4	73.7
2,000	65	69.7	58.4	75.1
2,500	65.2	70.1	58.4	75.3
3,150	54.9	57.7	53.6	65
4,000	55	59.2	52.8	65
5,000	54.5	57.7	52.1	64.5
6,300	54.6	59.2	51.7	64.7
8,000	54.1	55.4	53.2	64.2
10,000	53.6	54.7	52.4	63.6
12,500	52.7	54.7	51.3	62.7
16,000	52.3	55.4	49.8	62.4
20,000	44	50.6	43.1	54.1

Test 6

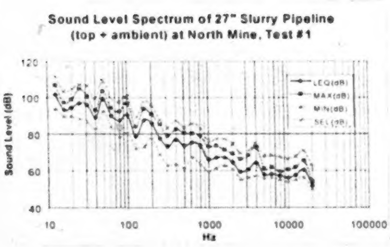
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	94.8	101.2	87.3	104.9
16	89.6	92.9	86.9	99.7
20	97.6	101.9	91.8	107.7
25	97.6	102.3	87.7	107.7
31.5	99.4	104.6	92.2	109.5
40	94.5	98.6	89.6	104.5
50	89.2	95.2	81.3	99.3
63	87.3	91.1	81.7	97.4
80	90.9	97.4	79.8	101
100	84.3	88.8	73.1	94.4
125	87.1	95.6	76.1	97.2
160	81.3	85.1	75.7	91.4
200	84.6	88.8	76.8	94.7
250	81.3	87.3	74.6	91.3
315	76.2	80.9	71.6	86.3
400	77.1	81.3	72.3	87.2
500	77	81.3	72.7	87.1
630	68.6	73.8	62.9	78.7
800	67.6	71.9	62.9	77.7
1,000	66	70.1	61.1	76.1
1,250	68.1	71.9	58.4	78.2
1,600	73.6	79.4	57.7	83.7
2,000	70	75.7	62.2	80.1
2,500	58	61.4	55.4	68.1
3,150	54.3	55.4	53.2	64.4
4,000	52.6	54.7	51.7	62.7
5,000	55.2	59.9	50.9	65.3
6,300	53.4	55.1	51.7	63.5
8,000	53.3	54.7	52.1	63.4
10,000	53.2	54.7	52.4	63.3
12,500	52.8	55.8	51.3	62.9
16,000	53.2	55.8	51.3	63.3
20,000	46	49.1	44.6	56.1

Test 7

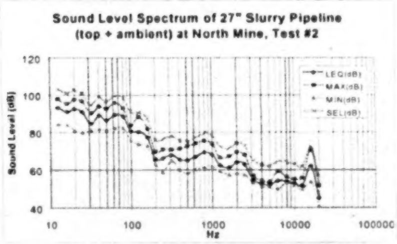
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	90.4	95.2	83.9	100.4
16	90.3	95.9	85.8	100.4
20	87.4	93.7	78.3	97.5
25	88.2	93.3	83.6	98.3
31.5	83	86.9	79.4	93.1
40	85.6	91.8	79.1	95.7
50	87.2	92.6	83.2	97.3
63	86.1	92.9	76.4	96.1
80	87.9	92.6	81.3	98
100	83.6	88.4	78.3	93.7
125	82.1	85.8	77.2	92.2
160	78.1	85.4	69.7	88.1
200	70.6	75.3	63.3	80.6
250	68.9	73.8	57.7	79
315	69.1	73.1	62.9	79.1
400	71.3	77.2	61.8	81.4
500	72.3	79.8	62.9	82.3
630	63.2	66.7	59.6	73.3
800	57.4	63.3	54.7	67.5
1,000	63	68.9	56.2	73.1
1,250	57.8	60.7	55.4	67.9
1,600	58.9	63.3	54.3	68.9
2,000	54.4	55.8	53.6	64.5
2,500	53.3	54.3	52.8	63.4
3,150	53.8	56.9	52.1	63.8
4,000	52	53.2	50.6	62.1
5,000	51.9	53.2	49.8	61.9
6,300	53.1	55.1	50.9	63.2
8,000	53.9	55.1	53.2	63.9
10,000	54.1	55.1	53.2	64.2
12,500	52.5	53.9	51.7	62.6
16,000	54.6	56.2	52.4	64.6
20,000	46.8	52.4	43.8	56.8

Test 8

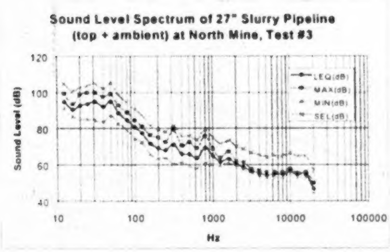
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	94.9	100.1	88.4	105
16	95.7	101.9	88.8	105.8
20	94.2	97.8	88.1	104.3
25	92.9	95.9	87.7	103
31.5	84.5	87.7	80.9	94.6
40	86.1	91.4	77.2	96.2
50	84.2	92.2	78.3	94.2
63	81.9	88.1	74.6	91.9
80	83	87.3	78.3	93.1
100	76	80.2	67.8	86.1
125	66.9	75.3	61.8	76.9
160	76.2	81.7	68.9	86.3
200	70.2	75.3	64.1	80.3
250	75.2	79.4	69.3	85.3
315	67.2	71.2	62.9	77.3
400	68.3	74.6	58.8	78.4
500	65.7	69.3	58.4	75.8
630	63.3	70.4	55.4	73.3
800	63.3	67.4	59.9	73.3
1,000	67.6	73.1	57.7	77.6
1,250	59.1	62.6	55.4	69.2
1,600	57.1	61.8	54.7	67.2
2,000	55.4	60.3	53.9	65.4
2,500	60.6	65.2	53.6	70.7
3,150	56.9	62.6	52.4	66.9
4,000	58.8	64.4	52.8	68.9
5,000	57.3	62.9	52.8	67.3
6,300	53.6	55.8	50.9	63.7
8,000	54.5	57.3	53.2	64.5
10,000	54.9	58.1	52.1	65
12,500	53.7	55.4	52.4	63.8
16,000	53.3	55.1	50.9	63.4
20,000	47.4	50.9	45.7	57.5



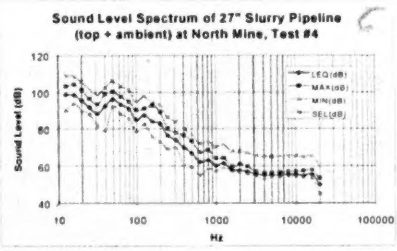
Sound Level Spectrum of 27" Slurry Pipeline (top + ambient) at North Mine, Test #1



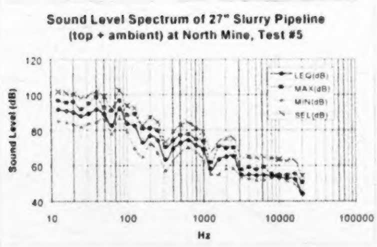
Sound Level Spectrum of 27" Slurry Pipeline (top + ambient) at North Mine, Test #2



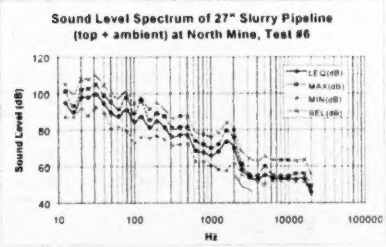
Sound Level Spectrum of 27" Slurry Pipeline (top + ambient) at North Mine, Test #3



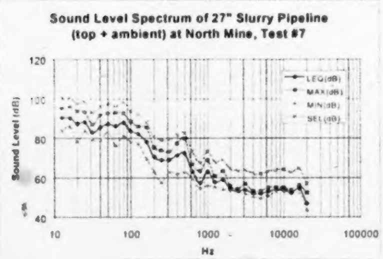
Sound Level Spectrum of 27" Slurry Pipeline (top + ambient) at North Mine, Test #4



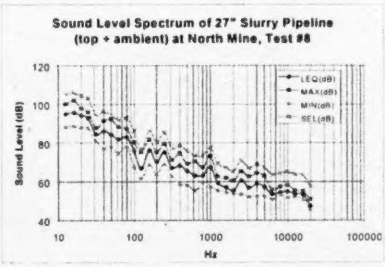
Sound Level Spectrum of 27" Slurry Pipeline (top + ambient) at North Mine, Test #5



Sound Level Spectrum of 27" Slurry Pipeline (top + ambient) at North Mine, Test #6



Sound Level Spectrum of 27" Slurry Pipeline (top + ambient) at North Mine, Test #7



Sound Level Spectrum of 27" Slurry Pipeline (top + ambient) at North Mine, Test #8

Top Pipeline Sound Level Spectrum Due to Slurry Flow
North Mine

Test #1				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	101.6	106.8	93.7	111.8
16	93.1	97.0	89.6	103.2
20	93.8	96.5	89.6	103.9
25	96.9	104.6	88.4	107.0
31.5	96.0	100.6	86.5	106.2
40	88.6	91.7	83.0	98.7
50	99.1	103.4	92.6	109.3
63	90.0	94.1	83.9	100.1
80	87.3	92.1	77.9	97.4
100	90.4	96.7	80.5	100.5
125	78.3	83.7	71.7	88.5
160	87.4	93.7	72.5	97.5
200	85.8	90.7	77.5	95.9
250	77.5	85.1	68.7	87.6
315	73.0	78.6	62.2	83.1
400	76.9	82.4	62.9	87.1
500	73.5	80.6	61.6	83.6
630	75.3	80.2	67.1	85.4
800	73.5	78.8	63.4	83.6
1000	65.5	72.8	59.3	75.6
1250	66.9	73.4	61.3	77.0
1600	67.0	71.2	62.8	77.2
2000	64.3	68.9	60.6	74.4
2500	55.8	63.3	55.0	66.2
3150	60.0	67.8	55.7	70.1
4000	64.0	72.6	57.0	74.1
5000	56.6	59.2	55.3	66.7
6300	57.9	61.6	56.0	68.0
8000	55.3	57.4	54.3	65.4
10000	53.4	55.3	52.4	63.5
12500	55.7	57.3	54.7	66.0
16000	60.2	65.0	56.0	70.3
20000	51.4	53.0	50.0	61.5

Test #2				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	92.6	97.3	82.7	102.7
16	89.7	93.9	82.0	99.8
20	91.7	96.8	73.8	101.8
25	90.2	96.3	75.3	100.3
31.5	81.9	87.5	80.0	92.0
40	88.8	93.4	81.4	98.9
50	86.4	92.5	81.1	96.5
63	89.2	95.5	82.1	99.3
80	88.2	92.6	82.1	98.3
100	80.4	83.2	75.3	90.5
125	79.0	87.7	72.4	89.1
160	75.4	79.8	71.3	85.5
200	62.0	67.6	58.8	72.2
250	64.1	68.4	50.5	74.2
315	66.9	69.4	64.0	77.0
400	63.5	70.5	55.9	73.6
500	54.5	62.8	52.3	61.5
630	66.7	74.1	59.9	76.8
800	69.2	75.3	61.2	79.3
1000	68.1	73.8	61.7	78.2
1250	62.0	66.1	58.9	72.1
1600	60.9	66.9	57.0	71.0
2000	63.8	69.1	57.8	73.9
2500	62.7	67.8	57.2	72.8
3150	54.2	56.3	52.6	64.3
4000	51.6	53.3	50.4	61.8
5000	51.2	52.7	50.0	61.3
6300	53.7	58.4	49.0	63.8
8000	51.8	54.4	51.5	61.9
10000	49.9	51.8	48.2	60.0
12500	50.5	53.6	49.1	60.6
16000	62.0	70.3	53.2	72.1
20000	38.5	47.6	38.7	52.2

Test #3				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	94.4	99.0	91.0	104.4
16	89.0	90.9	85.7	99.1
20	83.8	91.4	71.4	93.9
25	93.4	99.6	85.1	103.5
31.5	94.3	98.0	83.7	104.3
40	91.9	97.4	83.5	102.0
50	95.0	98.9	87.3	105.0
63	88.5	92.6	82.4	98.6
80	84.5	88.7	78.8	94.5
100	80.4	84.1	73.7	90.4
125	76.8	80.6	71.4	86.9
160	70.1	75.2	62.3	80.2
200	68.5	74.7	61.7	78.5
250	67.6	72.1	62.9	77.7
315	70.9	79.1	59.5	81.0
400	65.6	70.2	61.0	75.7
500	65.6	72.3	58.9	75.7
630	63.4	68.9	57.9	73.5
800	69.3	75.7	61.3	79.3
1000	64.7	68.6	60.1	74.7
1250	61.4	63.6	59.5	71.5
1600	63.0	67.1	61.0	73.1
2000	59.8	61.7	58.7	69.9
2500	58.5	61.0	57.2	68.5
3150	56.0	57.1	55.2	66.1
4000	54.7	56.2	53.4	64.7
5000	53.6	55.3	52.3	63.5
6300	54.5	55.5	52.8	64.6
8000	53.3	54.7	51.9	63.4
10000	55.1	56.8	53.6	65.2
12500	54.3	55.0	53.0	64.3
16000	54.3	55.5	52.9	64.3
20000	46.2	49.4	44.5	56.3

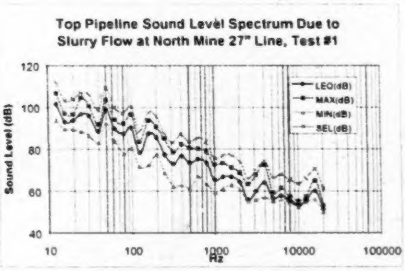
Test #4				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	98.7	103.1	90.3	108.8
16	98.3	104.2	93.7	108.4
20	95.6	101.2	90.3	105.7
25	91.6	96.3	88.1	101.7
31.5	88.3	93.1	81.7	98.4
40	92.4	98.9	79.4	102.5
50	96.1	100.1	92.2	106.1
63	93.0	97.4	88.1	103.0
80	90.9	94.8	85.8	101.0
100	84.8	90.3	78.9	94.8
125	87.5	91.1	82.3	97.6
160	83.9	92.6	75.5	93.9
200	82.8	89.2	72.8	92.8
250	76.3	80.1	69.0	86.3
315	73.7	77.8	69.5	83.8
400	69.6	76.2	59.4	79.7
500	66.9	73.4	59.3	76.9
630	62.0	67.3	54.6	72.1
800	62.9	68.5	58.5	72.9
1000	59.9	63.9	56.9	70.0
1250	61.1	63.9	58.9	71.1
1600	57.2	59.0	56.5	67.3
2000	57.1	60.4	56.1	67.2
2500	56.7	59.4	55.6	66.7
3150	55.1	56.4	53.9	65.2
4000	54.4	55.6	52.7	64.3
5000	54.5	55.7	53.5	64.5
6300	54.6	56.2	53.5	64.7
8000	54.2	55.9	53.2	64.1
10000	53.8	55.5	52.7	63.9
12500	54.6	57.0	53.5	64.6
16000	55.1	57.5	53.3	65.2
20000	49.7	53.0	44.8	59.8

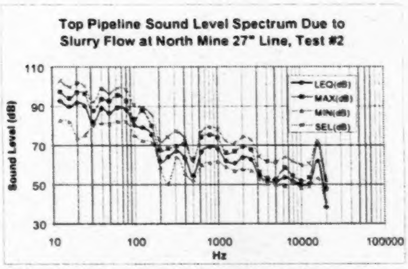
Test #5				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	91.6	96.7	85.4	101.7
16	90.7	95.5	84.2	100.8
20	90.0	95.8	83.5	100.1
25	87.8	91.6	82.0	97.9
31.5	88.9	94.5	83.9	99.0
40	91.6	98.6	84.6	101.6
50	89.0	92.6	86.6	99.1
63	82.3	91.0	77.8	92.3
80	92.2	96.7	86.9	102.2
100	83.7	88.4	79.3	93.7
125	82.4	89.2	69.0	92.5
160	72.6	81.2	63.5	82.6
200	76.9	81.3	72.2	87.0
250	74.3	79.8	66.9	84.4
315	63.0	70.3	56.4	73.1
400	69.4	74.2	62.7	79.4
500	72.8	77.2	67.8	82.9
630	74.4	77.6	70.1	84.5
800	71.4	74.9	67.8	81.4
1000	69.0	73.8	63.2	79.0
1250	57.5	61.5	54.8	67.5
1600	63.5	70.8	55.0	73.6
2000	65.0	69.7	58.2	75.1
2500	65.2	70.1	58.3	75.3
3150	54.5	57.4	53.2	64.6
4000	54.5	59.0	52.1	64.5
5000	54.0	57.4	51.5	64.0
6300	54.3	59.1	51.2	64.4
8000	52.4	53.8	51.8	62.5
10000	51.2	52.0	50.0	61.2
12500	52.2	53.8	51.0	62.2
16000	51.7	55.0	48.9	61.8
20000	38.7	46.7	41.6	48.8

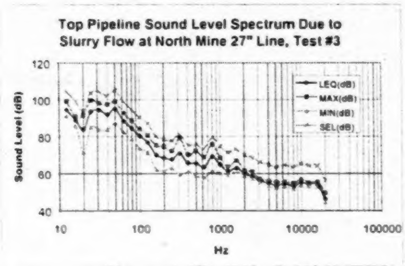
Test #6				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	94.7	101.2	87.2	104.8
16	89.6	92.9	86.9	99.7
20	97.6	101.9	91.8	107.7
25	97.6	102.3	87.7	107.7
31.5	99.4	104.6	92.2	109.5
40	94.5	98.5	89.6	104.5
50	89.2	95.2	81.3	99.3
63	87.3	91.1	81.7	97.4
80	90.8	97.3	79.7	100.9
100	84.3	88.8	72.9	94.4
125	87.1	95.6	76.0	97.2
160	81.2	85.0	75.6	91.3
200	84.6	88.8	76.7	94.7
250	81.3	87.3	74.5	91.3
315	76.2	80.9	71.6	86.3
400	77.1	81.3	72.3	87.2
500	77.0	81.3	72.7	87.1
630	68.5	73.7	62.8	78.6
800	67.4	71.7	62.8	77.5
1000	65.9	70.0	61.0	76.0
1250	68.0	71.5	58.1	78.1
1600	73.5	79.4	57.2	83.6
2000	70.0	75.7	62.2	80.1
2500	57.9	61.3	55.3	68.0
3150	53.9	55.0	52.8	64.0
4000	51.6	53.9	50.9	61.7
5000	54.8	59.7	50.0	64.9
6300	53.0	54.7	51.2	63.1
8000	51.0	52.6	50.2	61.1
10000	50.5	52.0	50.0	60.6
12500	52.3	55.1	51.0	62.4
16000	52.6	55.0	50.8	62.8
20000	43.9	45.2	43.7	54.0

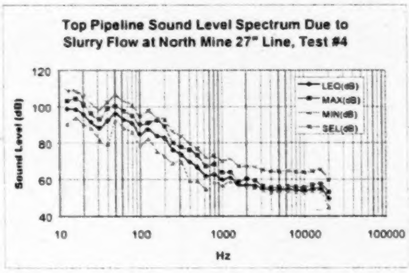
Test #7				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	90.2	95.0	83.5	100.2
16	89.9	95.5	85.7	100.0
20	87.2	93.5	77.9	97.3
25	88.1	93.1	83.5	98.2
31.5	82.4	86.4	78.8	92.5
40	85.5	91.7	78.8	95.6
50	87.2	92.6	83.2	97.3
63	86.0	92.8	76.2	96.0
80	87.9	92.6	81.2	98.0
100	83.5	88.3	78.2	93.6
125	81.9	85.6	76.9	92.0
160	77.8	85.3	68.4	87.8
200	70.0	75.0	60.6	80.0
250	68.5	73.6	50.0	78.6
315	69.0	73.0	62.5	79.0
400	71.2	77.2	61.5	81.3
500	72.3	79.8	62.8	82.3
630	63.1	66.6	59.5	73.2
800	56.2	62.4	54.0	66.3
1000	62.9	68.8	55.8	73.0
1250	57.3	60.3	54.7	67.4
1600	58.7	63.1	53.9	68.7
2000	54.0	55.3	53.3	64.1
2500	53.1	54.0	52.7	63.2
3150	53.2	56.5	51.6	63.2
4000	50.9	52.1	49.5	61.0
5000	51.1	52.4	48.7	61.1
6300	52.6	54.6	50.3	62.7
8000	51.9	53.0	51.7	61.8
10000	51.8	52.8	51.1	61.9
12500	52.2	53.3	51.5	62.3
16000	54.2	55.4	52.1	64.1
20000	44.5	47.7	42.7	54.4

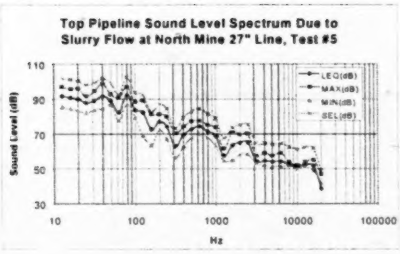
Test #8				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	94.4	100.0	88.4	104.5
16	95.7	101.9	88.8	105.8
20	94.1	97.6	88.1	104.2
25	92.9	95.8	87.7	103.0
31.5	84.0	86.9	80.8	94.3
40	86.0	91.2	77.0	96.0
50	84.1	92.2	78.1	94.1
63	81.8	88.0	74.5	91.8
80	82.8	87.1	78.2	92.9
100	75.7	79.9	66.9	85.9
125	65.5	75.0	58.8	75.5
160	76.1	81.7	68.5	86.2
200	69.8	75.0	63.2	79.9
250	75.1	79.3	69.1	85.2
315	67.0	70.9	62.5	77.1
400	68.2	74.5	58.1	78.3
500	65.5	69.1	57.8	75.6
630	63.2	70.4	55.0	73.2
800	63.2	67.4	59.8	73.2
1000	67.6	73.1	57.5	77.6
1250	58.9	62.4	55.1	69.0
1600	56.9	61.7	54.4	67.0
2000	55.2	60.2	53.7	65.2
2500	60.6	65.2	53.5	70.7
3150	56.7	62.5	52.0	66.7
4000	58.6	64.3	52.3	68.7
5000	57.1	62.8	52.2	67.1
6300	53.2	55.5	50.3	63.3
8000	52.8	56.3	51.7	62.8
10000	53.3	57.2	49.4	63.4
12500	53.4	54.9	52.2	63.5
16000	52.7	53.8	50.3	62.8
20000	47.1	50.6	45.4	57.2

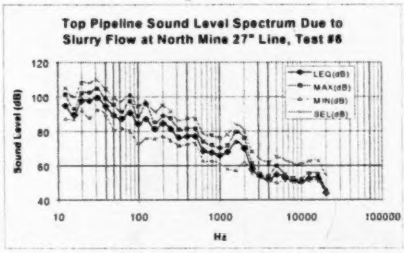

Top Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #1

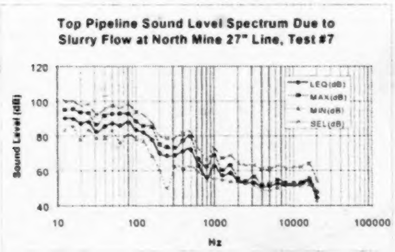

Top Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #2

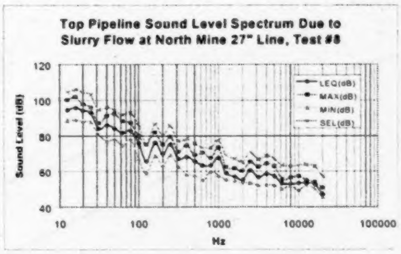

Top Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #3


Top Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #4


Top Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #5


Top Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #6


Top Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #7


Top Pipeline Sound Level Spectrum Due to Slurry Flow at North Mine 27" Line, Test #8

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow
North Mine

Test #1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	114.0	119.2	106.1	124.2	12.4
16	107.7	111.6	104.1	117.8	14.5
20	110.3	113.0	106.0	120.4	16.5
25	115.3	123.0	106.8	125.4	18.4
31.5	116.4	121.1	107.0	126.6	20.4
40	111.1	114.2	105.5	121.2	22.5
50	123.5	127.8	117.0	133.7	24.4
63	116.4	120.5	110.3	126.5	26.5
80	115.8	120.6	106.4	125.9	28.5
100	120.8	127.2	110.9	130.9	30.5
125	110.7	116.1	104.1	121.0	32.4
160	122.0	128.2	107.0	132.1	34.5
200	122.3	127.2	114.0	132.4	36.5
250	115.9	123.5	107.1	126.0	38.4
315	113.5	119.0	102.6	123.6	40.4
400	119.4	124.9	105.4	129.6	42.5
500	117.9	125.0	106.1	128.0	44.4
630	121.7	126.6	113.5	131.8	46.5
800	122.0	127.4	112.0	132.1	48.5
1000	115.9	123.3	109.7	126.0	50.5
1250	119.3	125.8	113.7	129.4	52.4
1600	121.5	125.7	117.4	131.7	54.5
2000	120.7	125.3	117.1	130.9	56.5
2500	114.3	121.7	113.4	124.6	58.4
3150	120.4	128.2	116.1	130.5	60.4
4000	126.5	136.1	119.5	136.6	62.5
5000	121.1	123.6	119.7	131.2	64.4
6300	124.3	128.1	122.4	134.4	66.5
8000	123.8	125.9	122.9	133.9	68.5
10000	123.8	125.8	122.9	133.9	70.5
12500	128.1	129.7	127.1	138.4	72.4
16000	134.8	139.6	130.5	144.9	74.5
20000	127.9	129.5	126.5	138.0	76.5

Test #2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	105.0	109.7	95.1	115.1	12.4
16	104.3	108.5	96.5	114.4	14.5
20	108.2	113.3	90.3	118.3	16.5
25	108.7	114.8	93.7	118.8	18.4
31.5	102.3	108.0	100.4	112.4	20.4
40	111.3	115.9	103.9	121.4	22.5
50	110.8	117.0	105.6	120.9	24.4
63	115.6	121.9	108.5	125.7	26.5
80	116.7	121.1	110.7	126.8	28.5
100	110.9	113.7	105.8	121.0	30.5
125	111.4	120.1	104.8	121.5	32.4
160	109.9	114.3	105.8	120.0	34.5
200	98.5	104.0	95.3	108.7	36.5
250	102.5	106.8	89.0	112.6	38.4
315	107.4	109.8	104.5	117.5	40.4
400	106.0	113.0	98.4	116.1	42.5
500	99.0	107.2	96.8	106.0	44.4
630	113.2	120.6	106.3	123.3	46.5
800	117.8	123.8	109.7	127.9	48.5
1000	118.5	124.2	112.2	128.6	50.5
1250	114.4	118.5	111.3	124.5	52.4
1600	115.4	121.4	111.6	125.5	54.5
2000	120.3	125.6	114.3	130.4	56.5
2500	121.2	126.2	115.6	131.3	58.4
3150	114.7	116.7	113.0	124.8	60.4
4000	114.1	115.8	112.9	124.3	62.5
5000	115.7	117.2	114.5	125.8	64.4
6300	120.1	124.9	115.5	130.2	66.5
8000	120.3	122.9	120.0	130.4	68.5
10000	120.3	122.2	118.7	130.4	70.5
12500	122.9	126.0	121.5	133.0	72.4
16000	136.5	144.8	127.7	146.6	74.5
20000	115.0	124.1	115.1	128.7	76.5

Test #3

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	106.9	111.4	103.4	116.8	12.4
16	103.5	105.4	100.2	113.6	14.5
20	100.3	107.9	87.9	110.4	16.5
25	111.8	118.1	103.5	121.9	18.4
31.5	114.7	118.4	104.1	124.7	20.4
40	114.4	119.9	106.0	124.5	22.5
50	119.4	123.3	111.7	129.4	24.4
63	114.9	119.0	108.8	125.0	26.5
80	113.0	117.2	107.4	123.0	28.5
100	110.9	114.6	104.1	120.9	30.5
125	109.2	113.0	103.8	119.3	32.4
160	104.7	109.8	96.8	114.8	34.5
200	106.0	111.2	98.2	115.0	36.5
250	106.1	110.5	101.4	116.2	38.4
315	111.3	119.5	100.0	121.4	40.4
400	108.2	112.7	103.5	118.3	42.5
500	110.0	116.7	103.3	120.1	44.4
630	109.9	115.3	104.3	120.0	46.5
800	117.8	124.2	109.8	127.8	48.5
1000	115.2	119.0	110.6	125.2	50.5
1250	113.8	116.0	111.9	123.9	52.4
1600	117.6	121.6	115.6	127.7	54.5
2000	116.3	118.1	115.2	126.4	56.5
2500	116.9	119.5	115.7	126.9	58.4
3150	116.5	117.5	115.6	126.6	60.4
4000	117.2	118.7	115.9	127.2	62.5
5000	118.0	119.7	116.7	128.0	64.4
6300	120.9	121.9	119.3	131.0	66.5
8000	121.9	123.2	120.5	132.0	68.5
10000	125.5	127.2	124.0	135.6	70.5
12500	126.7	127.4	125.4	136.7	72.4
16000	128.8	130.1	127.5	138.8	74.5
20000	122.7	125.9	121.0	132.8	76.5

Test #4

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	111.1	115.5	102.7	121.2	12.4
16	112.8	118.7	108.2	122.9	14.5
20	112.1	117.7	106.8	122.2	16.5
25	110.0	114.7	106.5	120.1	18.4
31.5	108.7	113.5	102.1	118.8	20.4
40	114.9	121.4	101.9	125.0	22.5
50	120.5	124.5	116.6	130.5	24.4
63	119.4	123.8	114.5	129.4	26.5
80	119.4	123.3	114.3	129.5	28.5
100	115.3	120.7	109.4	125.3	30.5
125	119.9	123.5	114.7	130.0	32.4
160	118.4	127.1	110.1	128.4	34.5
200	119.2	125.7	109.3	129.2	36.5
250	114.7	118.6	107.4	124.7	38.4
315	114.1	118.3	110.0	124.2	40.4
400	112.1	118.7	101.9	122.2	42.5
500	111.4	117.8	103.7	121.4	44.4
630	108.4	113.8	101.0	118.5	46.5
800	111.4	117.0	107.0	121.4	48.5
1000	110.4	114.4	107.3	120.5	50.5
1250	113.5	116.3	111.3	123.5	52.4
1600	111.7	113.5	111.0	121.8	54.5
2000	113.6	116.8	112.6	123.7	56.5
2500	115.2	117.8	114.0	125.1	58.4
3150	115.5	116.8	114.3	125.6	60.4
4000	116.9	118.1	115.2	126.8	62.5
5000	118.9	120.2	117.9	128.9	64.4
6300	121.1	122.6	120.0	131.2	66.5
8000	122.7	124.4	121.7	132.7	68.5
10000	124.2	126.0	123.2	134.3	70.5
12500	127.0	129.4	125.9	137.0	72.4
16000	129.7	132.0	127.9	139.8	74.5
20000	126.2	129.5	121.3	136.3	76.5

Test #5

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	104.0	109.1	97.8	114.1	12.4
16	105.3	110.1	98.7	115.4	14.5
20	106.5	112.3	100.0	116.6	16.5
25	106.2	110.1	100.4	116.3	18.4
31.5	109.4	114.9	104.3	119.5	20.4
40	114.1	121.1	107.1	124.1	22.5
50	113.4	117.0	111.0	123.5	24.4
63	108.8	117.5	104.2	118.8	26.5
80	120.7	125.2	115.4	130.7	28.5
100	114.1	118.8	109.8	124.1	30.5
125	114.8	121.6	101.4	124.9	32.4
160	107.1	115.7	98.0	117.1	34.5
200	113.4	117.7	108.7	123.5	36.5
250	112.7	118.2	105.3	122.8	38.4
315	103.4	110.7	96.9	113.5	40.4
400	111.9	116.7	105.2	121.9	42.5
500	117.2	121.6	112.2	127.3	44.4
630	120.8	124.0	116.5	130.9	46.5
800	119.9	123.4	116.3	129.9	48.5
1000	119.4	124.2	113.7	129.4	50.5
1250	109.9	113.9	107.2	119.9	52.4
1600	118.1	125.3	109.5	128.2	54.5
2000	121.4	126.2	114.7	131.5	56.5
2500	123.6	128.5	116.7	133.7	58.4
3150	114.9	117.8	113.6	125.0	60.4
4000	117.0	121.5	114.6	127.0	62.5
5000	118.5	121.9	115.9	128.5	64.4
6300	120.7	125.5	117.6	130.8	66.5
8000	120.9	122.4	120.3	131.0	68.5
10000	121.6	122.5	120.4	131.6	70.5
12500	124.6	126.3	123.4	134.6	72.4
16000	126.2	129.5	123.4	136.4	74.5
20000	115.1	123.2	118.1	125.2	76.5

Test #6

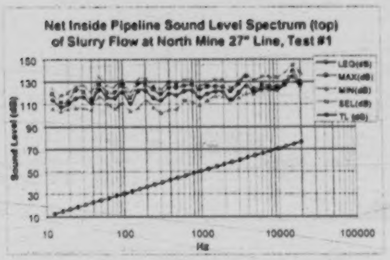
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	107.1	113.6	99.6	117.2	12.4
16	104.1	107.4	101.4	114.2	14.5
20	114.1	118.4	108.3	124.2	16.5
25	116.0	120.7	106.1	126.1	18.4
31.5	119.8	125.0	112.6	129.9	20.4
40	117.0	121.1	112.1	127.0	22.5
50	113.6	119.6	105.7	123.7	24.4
63	113.7	117.5	106.1	123.8	26.5
80	119.3	125.8	108.2	129.4	28.5
100	114.7	119.2	103.4	124.8	30.5
125	119.5	128.0	108.4	129.6	32.4
160	115.7	119.5	110.1	125.8	34.5
200	121.1	125.3	113.2	131.2	36.5
250	119.7	125.7	113.0	129.7	38.4
315	116.6	121.3	112.0	126.7	40.4
400	119.6	123.8	114.8	129.7	42.5
500	121.4	125.7	117.1	131.5	44.4
630	115.0	120.2	109.2	125.1	46.5
800	116.0	120.2	111.3	126.1	48.5
1000	116.4	120.5	111.4	126.5	50.5
1250	120.4	123.9	110.5	130.5	52.4
1600	128.1	133.9	111.7	138.2	54.5
2000	126.5	132.2	118.6	136.6	56.5
2500	116.3	119.7	113.7	126.4	58.4
3150	114.3	115.4	113.3	124.4	60.4
4000	114.1	116.4	113.4	124.2	62.5
5000	119.2	124.1	114.5	129.3	64.4
6300	119.4	121.2	117.7	129.5	66.5
8000	119.6	121.1	118.7	129.7	68.5
10000	120.9	122.5	120.4	131.1	70.5
12500	124.7	127.5	123.4	134.8	72.4
16000	127.2	129.6	125.4	137.3	74.5
20000	120.3	121.7	120.2	130.5	76.5

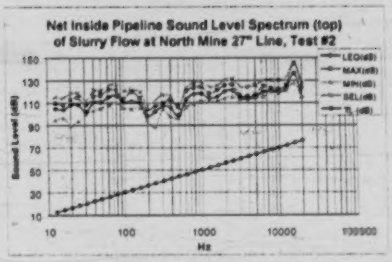
Test #7

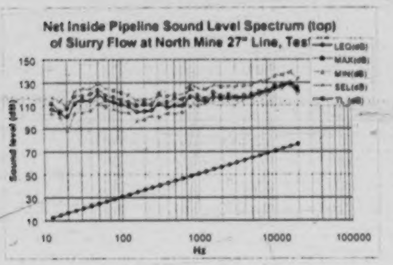
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	102.6	107.4	95.9	112.6	12.4
16	104.5	110.1	100.3	114.6	14.5
20	103.7	110.0	94.4	113.8	16.5
25	106.5	111.6	102.0	116.6	18.4
31.5	102.9	106.8	99.2	113.0	20.4
40	108.0	114.2	101.3	118.1	22.5
50	111.6	117.0	107.6	121.7	24.4
63	112.4	119.2	102.6	122.4	26.5
80	116.4	121.1	109.8	126.5	28.5
100	114.0	118.8	108.7	124.1	30.5
125	114.3	118.0	109.3	124.4	32.4
160	112.4	119.9	103.0	122.4	34.5
200	106.5	111.5	97.1	116.5	36.5
250	106.9	112.0	88.4	117.0	38.4
315	109.4	113.4	102.9	119.4	40.4
400	113.7	119.7	104.0	123.8	42.5
500	116.7	124.2	107.3	126.7	44.4
630	109.6	113.1	105.9	119.7	46.5
800	104.7	111.0	102.5	114.8	48.5
1000	113.3	119.3	106.3	123.4	50.5
1250	109.7	112.7	107.1	119.8	52.4
1600	113.2	117.7	108.4	123.2	54.5
2000	110.5	111.8	109.7	120.6	56.5
2500	111.5	112.5	111.1	121.6	58.4
3150	113.6	116.9	112.0	123.6	60.4
4000	113.4	114.6	112.0	123.5	62.5
5000	115.5	116.9	113.1	125.5	64.4
6300	119.1	121.1	116.8	129.2	66.5
8000	120.4	121.5	120.2	130.3	68.5
10000	122.3	123.2	121.5	132.4	70.5
12500	124.7	125.7	123.9	134.8	72.4
16000	128.7	130.0	126.6	138.7	74.5
20000	120.9	124.2	119.2	130.9	76.5

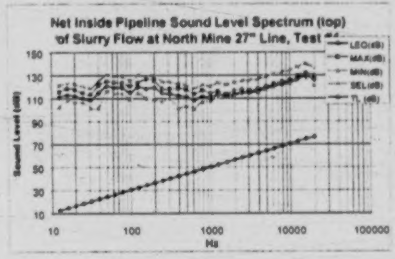
Test #8

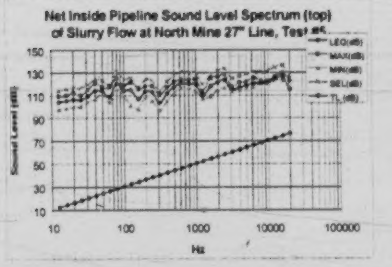
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	106.8	112.4	100.8	116.9	12.4
16	110.2	116.4	103.3	120.3	14.5
20	110.6	114.1	104.6	120.7	16.5
25	111.3	114.3	106.1	121.4	18.4
31.5	104.4	107.4	101.2	114.7	20.4
40	108.5	113.7	99.5	118.6	22.5
50	108.5	116.6	102.6	118.5	24.4
63	108.2	114.5	100.9	118.2	26.5
80	111.4	115.6	106.8	121.5	28.5
100	106.2	110.4	97.3	116.3	30.5
125	97.9	107.4	91.2	107.9	32.4
160	110.7	116.2	103.0	120.8	34.5
200	106.3	111.5	99.7	116.4	36.5
250	113.5	117.8	107.6	123.6	38.4
315	107.4	111.3	102.9	117.5	40.4
400	110.7	117.0	100.6	120.8	42.5
500	110.0	113.6	102.3	120.1	44.4
630	109.7	116.8	101.4	119.7	46.5
800	111.7	115.9	108.3	121.7	48.5
1000	118.0	123.6	108.0	128.0	50.5
1250	111.3	114.8	107.5	121.4	52.4
1600	111.4	116.2	109.0	121.5	54.5
2000	111.7	116.7	110.1	121.7	56.5
2500	119.0	123.6	111.9	129.1	58.4
3150	117.1	122.9	112.5	127.1	60.4
4000	121.1	126.8	114.8	131.2	62.5
5000	121.5	127.3	116.7	131.5	64.4
6300	119.7	121.9	116.7	129.8	66.5
8000	121.4	124.8	120.2	131.3	68.5
10000	123.8	127.6	119.9	133.9	70.5
12500	125.8	127.3	124.6	135.9	72.4
16000	127.3	128.4	124.8	137.4	74.5
20000	123.5	127.1	121.8	133.6	76.5

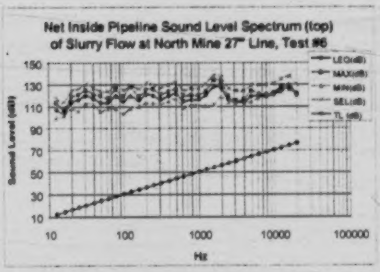

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #1

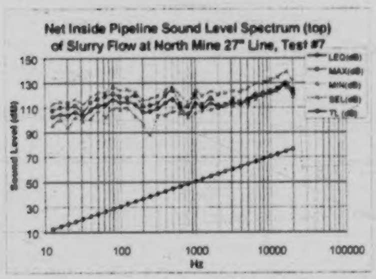

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #2

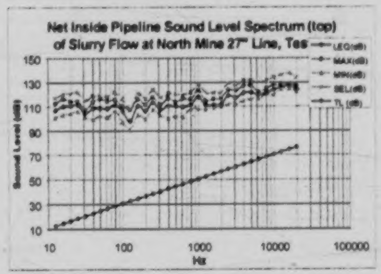

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Tes


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #5


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #6


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #7


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Tes

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow
North Mine

Test #1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	114.0	119.2	106.1	124.2
16	107.7	111.6	104.1	117.6
20	110.3	113.0	106.0	120.4
25	115.3	123.0	106.8	125.4
31.5	116.4	121.1	107.0	126.6
40	111.1	114.2	105.5	121.2
50	123.5	127.8	117.0	133.7
63	116.4	120.5	110.3	126.5
80	115.8	120.6	106.4	125.9
100	120.8	127.2	110.9	130.9
125	110.7	116.1	104.1	121.0
160	122.0	128.2	107.0	132.1
200	122.3	127.2	114.0	132.4
250	115.9	123.5	107.1	126.0
315	113.5	119.0	102.6	123.6
400	119.4	124.9	105.4	129.6
500	117.9	125.0	106.1	128.0
630	121.7	126.6	113.5	131.8
800	122.0	127.4	112.0	132.1
1000	115.9	123.3	109.7	126.0
1250	119.3	125.8	113.7	129.4
1600	121.5	125.7	117.4	131.7
2000	120.7	125.3	117.1	130.9
2500	114.3	121.7	113.4	124.6
3150	120.4	128.2	116.1	130.5
4000	126.5	135.1	119.5	136.6
5000	121.1	123.6	119.7	131.2
6300	124.3	128.1	122.4	134.4
8000	123.8	125.9	122.9	133.9
10000	123.8	125.8	122.9	133.9
12500	128.1	129.7	127.1	138.4
16000	134.8	139.6	130.5	144.9
20000	127.9	129.5	126.5	138.0

Test #2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	105.0	109.7	95.1	115.1
16	104.3	108.5	96.5	114.4
20	108.2	113.3	90.3	118.3
25	108.7	114.8	93.7	118.8
31.5	102.3	108.0	100.4	112.4
40	111.3	115.9	103.9	121.4
50	110.8	117.0	105.6	120.9
63	115.6	121.9	108.5	125.7
80	116.7	121.1	110.7	126.8
100	110.9	113.7	105.8	121.0
125	111.4	120.1	104.8	121.5
160	109.9	114.3	105.8	120.0
200	98.5	104.0	95.3	108.7
250	102.5	106.8	89.0	112.6
315	107.4	109.8	104.5	117.5
400	106.0	113.0	98.4	116.1
500	99.0	107.2	96.8	106.0
630	113.2	120.6	106.3	123.3
800	117.8	123.8	109.7	127.9
1000	118.5	124.2	112.2	128.6
1250	114.4	118.5	111.3	124.5
1600	115.4	121.4	111.6	125.5
2000	120.3	125.6	114.3	130.4
2500	121.2	126.2	115.6	131.3
3150	114.7	116.7	113.0	124.8
4000	114.1	115.8	112.9	124.3
5000	115.7	117.2	114.5	125.8
6300	120.1	124.9	115.5	130.2
8000	120.3	122.9	120.0	130.4
10000	120.3	122.2	118.7	130.4
12500	122.9	126.0	121.5	133.0
16000	136.5	144.8	127.7	146.6
20000	115.0	124.1	115.1	128.7

Test #3

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	106.9	111.4	103.4	116.8
16	103.5	105.4	100.2	113.6
20	100.3	107.9	87.9	110.4
25	111.8	118.1	103.5	121.9
31.5	114.7	118.4	104.1	124.7
40	114.4	119.9	106.0	124.5
50	119.4	123.3	111.7	129.4
63	114.9	119.0	108.8	125.0
80	113.0	117.2	107.4	123.0
100	140.9	114.6	104.1	120.9
125	109.2	113.0	103.8	119.3
160	104.7	109.8	96.8	114.8
200	105.0	111.2	98.2	115.0
250	106.1	110.5	101.4	116.2
315	111.3	119.5	100.0	121.4
400	108.2	112.7	103.5	118.3
500	110.0	116.7	103.3	120.1
630	109.9	115.3	104.3	120.0
800	117.8	124.2	109.8	127.8
1000	115.2	119.0	110.6	125.2
1250	113.8	116.0	111.9	123.9
1600	117.6	121.6	115.6	127.7
2000	116.3	118.1	115.2	126.4
2500	116.9	119.5	115.7	126.9
3150	116.5	117.5	115.6	126.6
4000	117.2	118.7	115.9	127.2
5000	118.0	119.7	116.7	128.0
6300	120.9	121.9	119.3	131.0
8000	121.9	123.2	120.5	132.0
10000	125.5	127.2	124.0	135.6
12500	126.7	127.4	125.4	136.7
16000	128.8	130.1	127.5	138.8
20000	122.7	125.9	121.0	132.8

Test #4

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	111.1	115.5	102.7	121.2
16	112.8	118.7	108.2	122.9
20	112.1	117.7	106.8	122.2
25	110.0	114.7	106.5	120.1
31.5	108.7	113.5	102.1	118.8
40	114.9	121.4	101.9	125.0
50	120.5	124.5	116.6	130.5
63	119.4	123.8	114.5	129.4
80	119.4	123.3	114.3	129.5
100	115.3	120.7	109.4	125.3
125	119.9	123.5	114.7	130.0
160	118.4	127.1	110.1	128.4
200	119.2	125.7	109.3	129.2
250	114.7	118.6	107.4	124.7
315	114.1	118.3	110.0	124.2
400	112.1	118.7	101.9	122.2
500	111.4	117.8	103.7	121.4
630	108.4	113.8	101.0	118.5
800	111.4	117.0	107.0	121.4
1000	110.4	114.4	107.3	120.5
1250	113.5	116.3	111.3	123.5
1600	111.7	113.5	111.0	121.8
2000	113.6	116.8	112.6	123.7
2500	115.2	117.8	114.0	125.1
3150	115.5	116.8	114.3	125.6
4000	116.9	118.1	115.2	126.8
5000	118.9	120.2	117.9	128.9
6300	121.1	122.6	120.0	131.2
8000	122.7	124.4	121.7	132.7
10000	124.2	126.0	123.2	134.3
12500	127.0	129.4	125.9	137.0
16000	129.7	132.0	127.9	139.8
20000	126.2	129.5	121.3	136.3

Test #5

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	104.0	109.1	97.8	114.1
16	105.3	110.1	98.7	115.4
20	106.5	112.3	100.0	116.6
25	106.2	110.1	100.4	116.3
31.5	109.4	114.9	104.3	119.5
40	114.1	121.1	107.1	124.1
50	113.4	117.0	111.0	123.5
63	108.8	117.5	104.2	118.8
80	120.7	125.2	115.4	130.7
100	114.1	118.8	109.8	124.1
125	114.8	121.6	101.4	124.9
160	107.1	115.7	98.0	117.1
200	113.4	117.7	108.7	123.5
250	112.7	118.2	105.3	122.8
315	103.4	110.7	96.9	113.5
400	111.9	116.7	105.2	121.9
500	117.2	121.6	112.2	127.3
630	120.8	124.0	116.5	130.9
800	119.9	123.4	116.3	129.9
1000	119.4	124.2	113.7	129.4
1250	109.9	113.9	107.2	119.9
1600	118.1	125.3	109.5	128.2
2000	121.4	126.2	114.7	131.5
2500	123.6	128.5	116.7	133.7
3150	114.9	117.8	113.6	125.0
4000	117.0	121.5	114.6	127.0
5000	118.5	121.9	115.9	128.5
6300	120.7	125.5	117.6	130.8
8000	120.9	122.4	120.3	131.0
10000	121.6	122.5	120.4	131.6
12500	124.6	126.3	123.4	134.6
16000	126.2	129.5	123.4	136.4
20000	115.1	123.2	118.1	125.2

Test #6

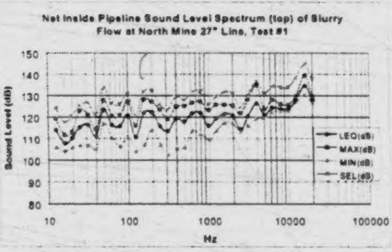
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	107.1	113.6	99.6	117.2
16	104.1	107.4	101.4	114.2
20	114.1	118.4	108.3	124.2
25	116.0	120.7	106.1	126.1
31.5	119.8	125.0	112.6	129.9
40	117.0	121.1	112.1	127.0
50	113.6	119.6	105.7	123.7
63	113.7	117.5	108.1	123.8
80	119.3	125.8	108.2	129.4
100	114.7	119.2	103.4	124.8
125	119.5	128.0	108.4	129.6
160	115.7	119.5	110.1	125.8
200	121.1	125.3	113.2	131.2
250	119.7	125.7	113.0	129.7
315	116.6	121.3	112.0	126.7
400	119.6	123.8	114.8	129.7
500	121.4	125.7	117.1	131.5
630	115.0	120.2	109.2	125.1
800	116.0	120.2	111.3	126.1
1000	116.4	120.5	111.4	126.5
1250	120.4	123.9	110.5	130.5
1600	128.1	133.9	111.7	138.2
2000	126.5	132.2	118.6	136.6
2500	116.3	119.7	113.7	126.4
3150	114.3	115.4	113.3	124.4
4000	114.1	116.4	113.4	124.2
5000	119.2	124.1	114.5	129.3
6300	119.4	121.2	117.7	129.5
8000	119.6	121.1	118.7	129.7
10000	120.9	122.5	120.4	131.1
12500	124.7	127.5	123.4	134.8
16000	127.2	129.6	125.4	137.3
20000	120.3	121.7	120.2	130.5

Test #7

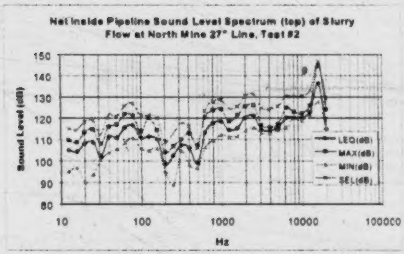
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	102.6	107.4	95.9	112.6
16	104.5	110.1	100.3	114.6
20	103.7	110.0	94.4	113.8
25	106.5	111.6	102.0	116.6
31.5	102.9	106.8	99.2	113.0
40	108.0	114.2	101.3	118.1
50	111.6	117.0	107.6	121.7
63	112.4	119.2	102.6	122.4
80	116.4	121.1	109.8	126.5
100	114.0	118.8	108.7	124.1
125	114.3	118.0	109.3	124.4
160	112.4	119.9	103.0	122.4
200	106.5	111.5	97.1	116.5
250	106.9	112.0	88.4	117.0
315	109.4	113.4	102.9	119.4
400	113.7	119.7	104.0	123.8
500	116.7	124.2	107.3	126.7
630	109.6	113.1	105.9	119.7
800	104.7	111.0	102.5	114.8
1000	113.3	119.3	106.3	123.4
1250	109.7	112.7	107.1	119.8
1600	113.2	117.7	108.4	123.2
2000	110.5	111.8	109.7	120.6
2500	111.5	112.5	111.1	121.6
3150	113.6	116.9	112.0	123.6
4000	113.4	114.6	112.0	123.5
5000	115.5	116.9	113.1	125.5
6300	119.1	121.1	116.8	129.2
8000	120.4	121.5	120.2	130.3
10000	122.3	123.2	121.5	132.4
12500	124.7	125.7	123.9	134.8
16000	128.7	130.0	126.6	138.7
20000	120.9	124.2	119.2	130.9

Test #8

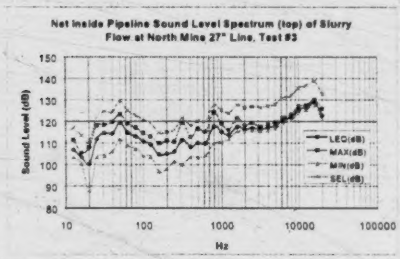
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	106.8	112.4	100.8	116.9
16	110.2	116.4	103.3	120.3
20	110.6	114.1	104.6	120.7
25	111.3	114.3	106.1	121.4
31.5	104.4	107.4	101.2	114.7
40	108.5	113.7	99.5	118.6
50	108.5	116.6	102.6	118.5
63	108.2	114.5	100.9	118.2
80	111.4	115.6	106.8	121.5
100	106.2	110.4	97.3	116.3
125	97.9	107.4	91.2	107.9
160	110.7	116.2	103.0	120.8
200	106.3	111.5	99.7	116.4
250	113.5	117.8	107.6	123.6
315	107.4	111.3	102.9	117.5
400	110.7	117.0	100.6	120.8
500	110.0	113.6	102.3	120.1
630	109.7	116.8	101.4	119.7
800	111.7	115.9	108.3	121.7
1000	118.0	123.6	108.0	128.0
1250	111.3	114.8	107.5	121.4
1600	111.4	116.2	109.0	121.5
2000	111.7	116.7	110.1	121.7
2500	119.0	123.6	111.9	129.1
3150	117.1	122.9	112.5	127.1
4000	121.4	126.8	114.8	131.2
5000	121.5	127.3	116.7	131.5
6300	119.7	121.9	116.7	129.8
8000	121.4	124.8	120.2	131.3
10000	123.8	127.6	119.9	133.9
12500	125.8	127.3	124.6	135.9
16000	127.3	128.4	124.8	137.4
20000	123.5	127.1	121.8	133.6



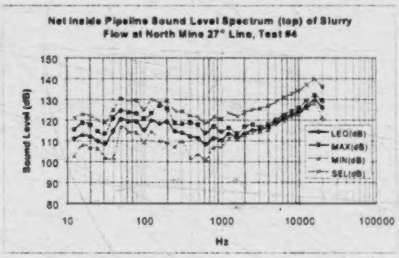
Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #1



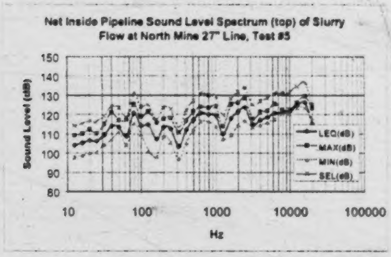
Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #2



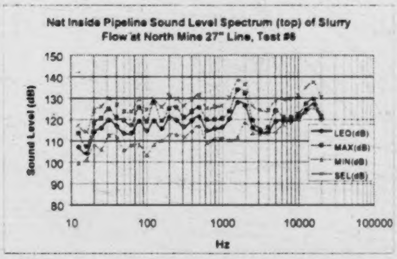
Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #3



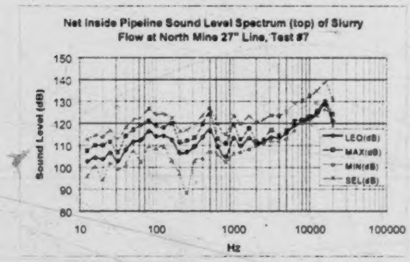
Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #4



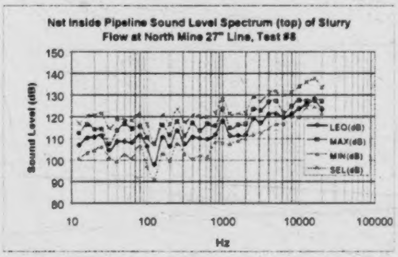
Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #5



Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #6



Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #7

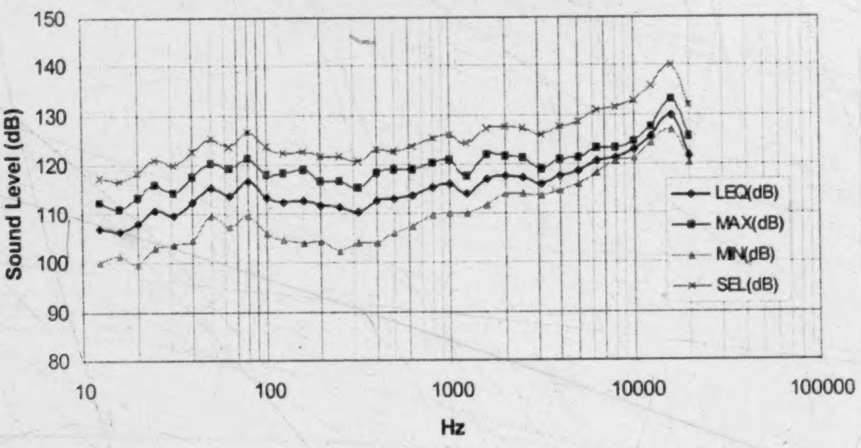


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line, Test #8

Average Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow

North Mine

Average				
FREQ(Hz)	**LEQ(dB)**	**MAX(dB)**	**MIN(dB)**	**SEL(dB)**
12.5	107.2	112.3	100.2	117.3
16	106.6	111.0	101.6	116.7
20	108.2	113.3	99.8	118.3
25	110.7	115.9	103.1	120.8
31.5	109.8	114.4	103.9	120.0
40	112.4	117.7	104.7	122.5
50	115.2	120.4	109.7	125.3
63	113.7	119.3	107.3	123.7
80	116.6	121.3	109.9	126.7
100	113.4	117.9	106.2	123.4
125	112.2	118.5	104.7	122.3
160	112.6	118.8	104.2	122.7
200	111.5	116.8	104.4	121.6
250	111.5	116.6	102.4	121.6
315	110.4	115.4	104.0	120.5
400	112.7	118.3	104.2	122.8
500	113.0	119.0	106.1	122.6
630	113.5	118.8	107.3	123.6
800	115.2	120.4	109.6	125.2
1000	115.9	121.1	109.9	126.0
1250	114.0	117.7	110.1	124.1
1600	117.1	121.9	111.8	127.2
2000	117.6	121.6	114.1	127.7
2500	117.2	121.2	114.0	127.3
3150	115.9	119.0	113.8	125.9
4000	117.5	120.9	114.8	127.6
5000	118.5	121.4	116.1	128.6
6300	120.7	123.4	118.2	130.8
8000	121.4	123.3	120.6	131.4
10000	122.8	124.6	121.4	132.9
12500	125.6	127.4	124.4	135.7
16000	129.9	133.0	126.7	140.0
20000	121.5	125.7	120.4	132.0
Overall	134.3	137.6	131.5	144.4



Average Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at North Mine 27" Line

7.5: Sound Level Measurement at Aurora Mine

7.5.1: Ambient

Ambient Sound Level Spectrum
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	58.6	61.1	56.2	69
16	50.9	54.3	46.7	61.1
20	52.4	54.3	49.8	62.5
25	61	63.3	59.2	71.2
31.5	59.5	61.4	57.7	69.6
40	61.5	65.2	57.7	71.6
50	58.6	60.7	57.3	68.7
63	60.3	62.9	57.7	70.5
80	60.4	62.9	57.7	70.6
100	61.7	64.1	59.6	71.8
125	58.9	60.3	57.7	69
160	57.2	59.2	54.7	67.4
200	54.2	56.2	52.8	64.4
250	48	50.9	46.1	58.2
315	53.1	62.2	42.7	63.3
400	47.9	50.6	46.4	58.1
500	45.7	47.2	44.2	55.8
630	42.8	44.9	41.2	52.9
800	45.3	46.8	43.4	55.4
1,000	40	41.6	38.9	50.1
1,250	40.4	43.1	38.6	50.5
1,600	40.8	44.6	37.4	51
2,000	36.5	38.2	34.8	46.6
2,500	36.2	39.7	33.3	46.3
3,150	44.1	45.3	42.7	54.3
4,000	45.5	46.4	43.1	55.6
5,000	44.4	45.3	43.8	54.6
6,300	42.8	43.8	41.9	53
8,000	50.8	51.7	48.7	61
10,000	49.1	50.2	48.3	59.3
12,500	39.6	44.6	37.8	49.8
16,000	43.2	44.6	41.2	53.3
20,000	35.8	39.7	33.3	46

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	57.4	59.9	54.3	67.5
16	56.5	60.7	50.2	66.6
20	51.3	54.7	46.7	61.3
25	53.1	55.4	50.2	63.2
31.5	55	57.3	53.2	65
40	57.3	59.6	55.4	67.4
50	60.2	62.6	57.3	70.3
63	61	63.3	58.4	71
80	59.4	61.8	56.9	69.4
100	56.8	58.1	55.8	66.8
125	60.7	61.8	58.1	70.8
160	56.6	57.7	55.8	66.7
200	54.3	55.8	53.2	64.4
250	46.4	48.3	45.3	56.4
315	48.6	50.2	46.4	58.7
400	44.1	45.7	43.4	54.2
500	46	47.9	44.2	56.1
630	41.7	44.6	40.4	51.8
800	41.7	43.8	40.8	51.7
1,000	39.1	40.8	37.8	49.2
1,250	39.3	40.8	37.8	49.4
1,600	38.1	39.7	37.1	48.2
2,000	37.1	39.3	35.6	47.2
2,500	33.8	35.2	32.6	43.8
3,150	44	45.3	41.2	54.1
4,000	45.5	46.4	44.2	55.6
5,000	44.1	45.3	43.4	54.2
6,300	42.8	44.2	41.9	52.8
8,000	50	50.9	48.3	60.1
10,000	49.6	50.9	48.7	59.7
12,500	39.4	44.6	37.8	49.5
16,000	42.6	44.2	40.8	52.7
20,000	35.2	38.9	33.3	45.3

Test 3

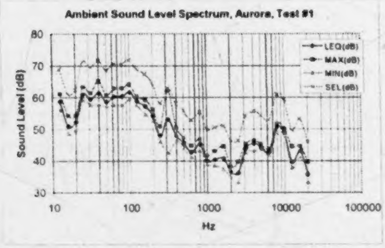
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	56.5	61.1	50.6	66.6
16	47.3	50.6	45.3	57.3
20	49	51.3	45.7	59.1
25	55.7	57.7	53.9	65.8
31.5	56.9	60.3	52.1	67
40	57.5	60.7	53.9	67.6
50	58.8	61.8	55.8	68.9
63	61.7	63.3	58.4	71.7
80	62.1	64.8	59.2	72.1
100	62.5	64.8	60.3	72.5
125	59.3	61.1	56.9	69.4
160	56.7	58.8	55.4	66.7
200	52.7	54.3	52.1	62.8
250	45.1	47.2	43.8	55.2
315	43.7	45.3	42.7	53.7
400	43.3	44.9	42.7	53.4
500	45.1	46.4	43.4	55.1
630	42.7	44.6	40.4	52.7
800	42.2	43.8	40.8	52.3
1,000	40.2	41.9	39.3	50.3
1,250	37	38.9	35.6	47.1
1,600	38.3	41.2	36.3	48.3
2,000	38.8	41.2	36.7	48.9
2,500	34.6	39.3	32.2	44.7
3,150	43.4	44.9	40.1	53.4
4,000	44.7	45.7	42.3	54.8
5,000	43.5	44.6	43.1	53.6
6,300	42.5	43.8	41.2	52.5
8,000	48.8	49.8	46.8	58.9
10,000	49.6	50.9	48.7	59.7
12,500	39.7	44.6	37.8	49.8
16,000	42.7	43.8	40.8	52.8
20,000	36.5	39.3	35.2	46.6

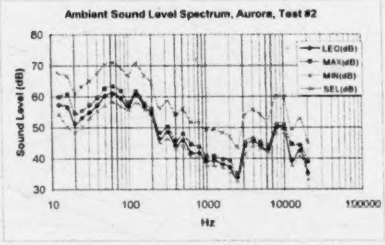
Test 4

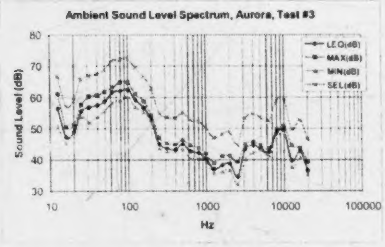
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	60.5	62.9	52.8	70.5
16	54.2	61.7	49.8	64.3
20	57.7	64.1	50.9	67.7
25	60.4	67.8	51.3	70.4
31.5	57	61.1	55.4	67.1
40	59.7	65.2	53.9	69.7
50	59.3	61.8	56.6	69.3
63	58.9	62.2	56.9	68.9
80	62.5	66.7	55.8	72.5
100	61.5	64.4	59.2	71.5
125	58.1	59.6	57.3	68.2
160	56.6	58.8	53.9	66.6
200	53.5	56.6	51.3	63.5
250	47.6	49.4	46.4	57.7
315	45.4	46.8	44.2	55.4
400	45.3	46.8	44.2	55.3
500	42	44.6	40.4	52.1
630	45.3	52.4	41.6	55.4
800	41.8	43.8	40.1	51.8
1,000	41.5	43.1	40.4	51.6
1,250	40.4	41.9	38.9	50.4
1,600	39.4	41.2	38.2	49.5
2,000	37.1	38.6	36.3	47.2
2,500	35.5	37.1	34.4	45.5
3,150	43.4	44.9	40.1	53.5
4,000	44.7	45.7	42.7	54.8
5,000	43.8	44.9	43.1	53.8
6,300	42.5	43.4	41.6	52.6
8,000	49	50.2	47.2	59.1
10,000	49.6	50.9	48.7	59.7
12,500	40	44.6	38.2	50
16,000	43	44.2	41.2	53
20,000	37.2	40.1	35.2	47.3

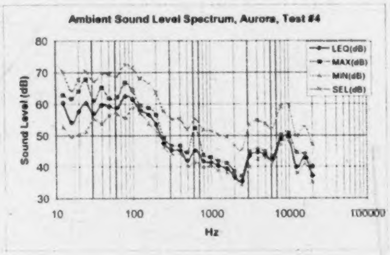
Test 5

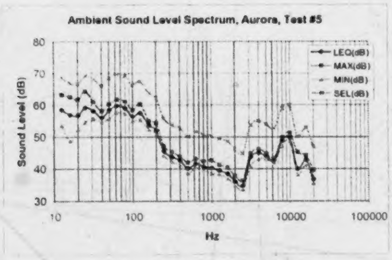
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	58.5	63.3	53.6	68.6
16	56.9	62.6	48.7	66.9
20	56.8	61.8	52.4	66.8
25	59.2	64.4	54.7	69.2
31.5	58.2	61.1	55.8	68.2
40	56	58.1	54.7	66
50	58.4	60.3	55.8	68.4
63	59.8	61.8	57.7	69.8
80	59	61.1	57.3	69.1
100	56.4	58.4	55.1	66.5
125	57.5	60.3	55.4	67.5
160	53.8	55.1	52.4	63.9
200	52	54.3	50.9	62.1
250	45.7	47.2	44.2	55.8
315	43.7	45.3	42.3	53.7
400	42.6	43.8	41.2	52.7
500	40.1	41.9	38.6	50.1
630	41.6	43.1	40.4	51.6
800	40.6	42.3	39.7	50.7
1,000	40.3	42.7	38.6	50.3
1,250	39.4	41.2	38.2	49.5
1,600	38.5	40.4	37.1	48.6
2,000	36.1	37.8	34.8	46.1
2,500	34.7	36.3	33.7	44.8
3,150	43.7	44.9	40.8	53.7
4,000	45	46.1	43.1	56.1
5,000	43.9	44.9	43.1	53.9
6,300	42.6	43.4	41.9	52.6
8,000	48.9	49.8	47.2	58.9
10,000	49.9	51.3	48.7	59.9
12,500	40	45.3	38.2	50.1
16,000	42.8	44.2	41.2	52.9
20,000	36.8	39.7	35.6	46.9


Ambient Sound Level Spectrum, Aurora, Test #1
Sound Level (dB)
80
70
60
50
40
30
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Ambient Sound Level Spectrum, Aurora, Test #2
Sound Level (dB)
80
70
60
50
40
30
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

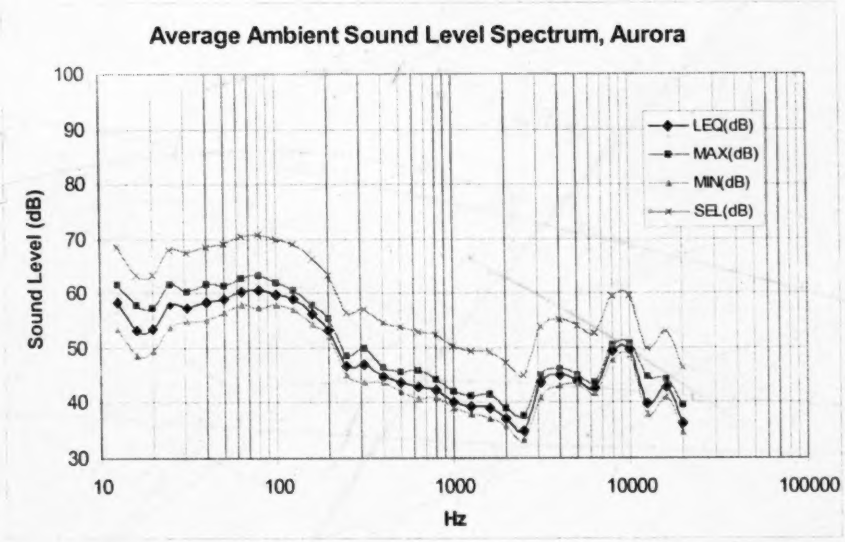

Ambient Sound Level Spectrum, Aurora, Test #3
Sound Level (dB)
80
70
60
50
40
30
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Ambient Sound Level Spectrum, Aurora, Test #4
Sound Level (dB)
80
70
60
50
40
30
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Ambient Sound Level Spectrum, Aurora, Test #5
Sound Level (dB)
80
70
60
50
40
30
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Average Ambient Sound Level Spectrum
Aurora Mine

Average FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	58.3	61.7	53.5	68.4
16	53.2	58.0	48.5	63.2
20	53.4	57.2	49.5	63.5
25	57.9	61.7	53.9	68.0
31.5	57.3	60.2	54.8	67.4
40	58.4	61.8	55.1	68.5
50	59.1	61.4	56.6	69.1
63	60.3	62.7	57.8	70.4
80	60.7	63.5	57.4	70.7
100	59.8	62.0	58.0	69.8
125	58.9	60.6	57.1	69.0
160	56.2	57.9	54.4	66.3
200	53.3	55.4	52.1	63.4
250	46.6	48.6	45.2	56.7
315	46.9	50.0	43.7	57.0
400	44.6	46.4	43.6	54.7
500	43.8	45.6	42.2	53.8
630	42.8	45.9	40.8	52.9
800	42.3	44.1	41.0	52.4
1000	40.2	42.0	39.0	50.3
1250	39.3	41.2	37.8	49.4
1600	39.0	41.4	37.2	49.1
2000	37.1	39.0	35.6	47.2
2500	35.0	37.5	33.2	45.0
3150	43.7	45.1	41.0	53.8
4000	45.1	46.1	43.1	55.2
5000	43.9	45.0	43.3	54.0
6300	42.6	43.7	41.7	52.7
8000	49.5	50.5	47.6	59.6
10000	49.6	50.8	48.6	59.7
12500	39.7	44.7	38.0	49.8
16000	42.9	44.2	41.0	52.9
20000	36.3	39.5	34.5	46.4
Overall	69.5	72.2	66.8	79.6


Average Ambient Sound Level Spectrum, Aurora
Sound Level (dB)
100
90
80
70
60
50
40
30
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

7.5.2: Pipeline Bottom

Bottom Sound Level Spectrum of 30" Slurry Pipeline
Aurora Mine

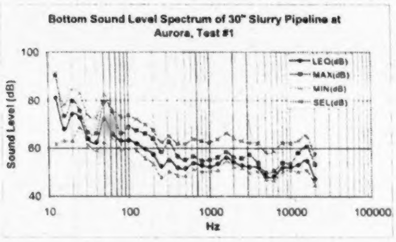
Test 1				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	81.2	90.3	61.8	91.3
16	68	73.4	63.3	78.1
20	74.4	79.8	63.3	84.5
25	72.7	75.7	68.9	82.9
31.5	64.1	66.7	61.4	74.2
40	62.5	66.3	59	72.7
50	72.2	79.2	62.7	82.3
63	66.2	75.4	64.6	76.3
80	63.1	66.3	59.6	73.2
100	63.4	68.9	60	73.5
125	61.9	67.4	59.2	72
160	59.6	66.1	55.8	69.8
200	57.4	64	53.4	67.5
250	52.4	58.4	47.9	62.6
315	55	62.7	50.2	65.1
400	51.8	56.6	48.7	61.9
500	51.6	55.1	48.7	61.7
630	53.7	56.6	51.3	63.9
800	52.8	54.7	50.2	62.9
1,000	52.2	55.1	50.6	62.4
1,250	53.5	56.2	50.9	63.7
1,600	56.1	58.4	54.7	66.2
2,000	54.1	56.2	52.4	64.2
2,500	52.8	55.8	51.7	62.9
3,150	52.2	57.3	49.8	62.3
4,000	52	53.9	50.6	62.1
5,000	48.1	49.8	47.2	58.2
6,300	48.5	50.6	46.8	58.6
8,000	51.9	53.9	50.2	62.1
10,000	52.1	53.6	50.9	62.2
12,500	53.1	58.1	50.2	63.2
16,000	54.8	60.7	50.9	64.9
20,000	47.1	53.2	44.6	57.3

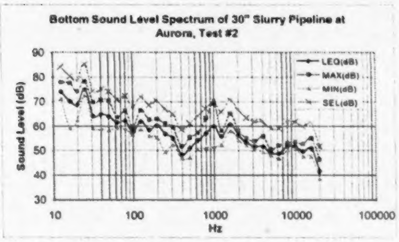
Test 2				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	74.2	77.9	71.2	84.3
16	70.2	77.6	59.2	80.3
20	68.7	74.2	62.6	78.8
25	75.1	78.3	72.7	85.2
31.5	64.2	69.7	59.2	74.3
40	64.9	70.8	58.8	75
50	64	70.4	58.4	74.1
63	61.5	63.6	59.2	71.1
80	62.2	66.3	58.8	72.3
100	57.9	59.9	56.6	68
125	62	66.5	58.7	72.1
160	58.5	62.6	56	68.6
200	60.4	62.9	55.4	70.4
250	56.9	61.1	49.4	67
315	55.1	59.6	52.4	65.1
400	48.4	51.7	46.8	58.5
500	51.1	55.4	47.2	61.2
630	54.1	57.3	50.6	64.2
800	57.1	63.3	51.1	67.2
1,000	60.1	69.3	51.7	70.2
1,250	55.8	58.1	52.4	65.9
1,600	60.8	65.2	58.1	70.9
2,000	56.3	58.1	54.3	66.4
2,500	53.3	55.1	52.1	63.4
3,150	51.8	53.9	50.6	61.9
4,000	51.7	55.8	49.4	61.8
5,000	49.1	50.6	48.3	59.2
6,300	48.8	52.1	46.8	58.9
8,000	51.9	53.2	50.3	62
10,000	51.8	53.6	51.2	61.8
12,500	49.7	52.8	47.6	59.8
16,000	51	55.1	47.6	61.1
20,000	41.6	46.4	38.6	51.7

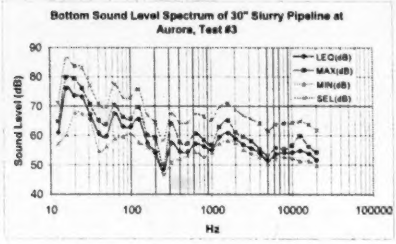
Test 3				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	61	64.8	57.3	71
16	76.1	79.8	60.3	86.1
20	73.7	79.4	67.8	83.7
25	73.2	76.1	67.4	83.2
31.5	67.2	70.8	65.6	77.2
40	60.8	65.2	54.7	70.9
50	59.7	63.8	56.4	69.7
63	67.5	70.4	59	77.5
80	63.1	66.3	59.6	73.2
100	63	65.7	60.8	73
125	65.6	69.7	57.7	75.7
160	57.5	60.1	56	67
200	54.3	59.2	53.1	64.4
250	48.4	50.2	46.8	58.4
315	57.4	64.1	50.9	67.4
400	54.5	57.7	52.1	64.5
500	54.4	57.3	53.2	64.5
630	57.2	60.7	54.3	67.3
800	56.4	58.4	52.8	66.4
1,000	55.1	56.9	54.3	65.2
1,250	59.5	62.9	57.3	69.6
1,600	60.9	65.2	58.4	70.9
2,000	58.9	61.1	57.7	68.9
2,500	56.9	59.6	55.1	66.9
3,150	55.6	58.1	53.9	65.7
4,000	54	55.4	52.8	64.1
5,000	51.5	53.2	50.2	61.5
6,300	53.6	55.8	52.1	63.7
8,000	54.1	55.4	52.8	64.2
10,000	54.2	56.6	52.4	64.3
12,500	54.8	59.9	51.3	64.8
16,000	53.8	56.2	51.3	63.8
20,000	51.6	54.3	49.8	61.7

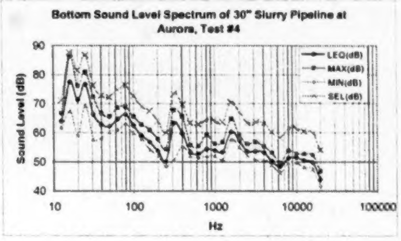
Test 4				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	64	66.7	61.8	71.2
16	77.5	86.2	67.4	87.6
20	71.3	76.1	59.2	81.3
25	76.6	80.9	69.3	86.7
31.5	66.4	72.3	57.7	76.4
40	62.8	66.7	58.4	72.8
50	62.2	65.6	60.3	72.3
63	64.7	68.6	61.1	74.7
80	66.3	69	63.1	76.4
100	62.6	65.6	60	72.7
125	59	62.8	58	69
160	56.8	61	54.2	67.6
200	53.7	57.8	52.1	64.1
250	50.1	54.4	48.6	60
315	63.3	67.8	50.6	73.3
400	59.8	65.6	55.4	69.8
500	53.4	55.8	52.1	63.4
630	52.8	55.5	51.3	62.9
800	54.5	59.2	52.1	64.5
1,000	54	56.2	52.1	64.1
1,250	53.5	56.9	50.9	63.5
1,600	60.4	64.8	57.7	70.5
2,000	57.3	59.2	55.1	67.3
2,500	53.6	56.2	52.4	63.6
3,150	53.7	56.9	50.6	63.7
4,000	53.3	55.4	50.9	63.3
5,000	50.3	53.2	49.1	60.4
6,300	48.5	49.8	46.4	58.5
8,000	51.4	53.9	49.8	61.4
10,000	51.5	52.8	49.8	61.6
12,500	50.5	52.8	48.3	60.5
16,000	49.9	52.4	47.6	59.9
20,000	44	46.8	41.9	54.1

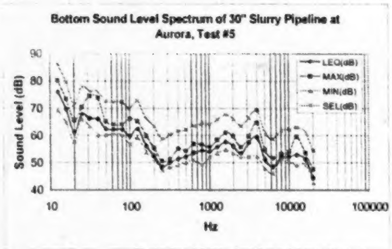
Test 5				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	76	80.2	69.3	86.1
16	69.7	73.4	64.8	79.8
20	61.3	65.6	57.7	71.3
25	67.8	70.4	65.9	77.9
31.5	66.3	74.6	63.3	76.4
40	66	73.8	60.3	76.1
50	62.5	65.2	60.3	72.6
63	62.2	64.1	60.7	72.3
80	62.3	64.1	60.3	72.3
100	59.8	66.1	56.9	69.9
125	62.5	65.2	59.2	72.6
160	56.1	59.9	53.9	66.2
200	52.5	55.4	51.4	63.5
250	48.5	50.6	47.2	58.6
315	50.1	51.3	48.3	60.2
400	51.4	55.1	49.1	61.4
500	52.2	54.3	50.2	62.2
630	53.6	56.9	50.9	63.6
800	54.4	56.6	49.4	64.4
1,000	54.1	55.8	52.1	64.2
1,250	55.8	58.4	53.6	65.8
1,600	57.6	61.1	54.7	67.7
2,000	56.1	59.9	53.6	66.1
2,500	53.4	55.8	52.1	63.5
3,150	57.4	59.8	52.3	66.5
4,000	59.4	64.8	52.4	69.4
5,000	51.3	54.7	47.9	61.3
6,300	48.6	51.7	46.1	58.7
8,000	51.9	53.2	51.3	62
10,000	52.2	53.9	50.6	62.3
12,500	52.9	59.6	49.1	63
16,000	51.3	53.6	49.4	61.3
20,000	44.4	47.6	42.7	54.5


Bottom Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #1


Bottom Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #2


Bottom Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #3


Bottom Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #4


Bottom Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #5

Bottom Pipeline Sound Level Spectrum Due to Slurry Flow
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	81.2	90.3	60.4	91.3
16	67.9	73.3	63.1	78.0
20	74.4	79.8	63.1	84.5
25	72.4	75.4	68.4	82.6
31.5	62.3	65.2	59.0	72.4
40	55.6	59.8	53.1	66.2
50	72.0	79.1	61.2	82.1
63	64.9	75.1	63.6	75.0
80	59.8	63.6	55.1	69.7
100	58.5	67.2	49.4	68.6
125	58.9	66.5	53.9	69.0
160	55.9	65.1	49.3	66.1
200	54.6	63.2	44.5	64.6
250	50.4	57.5	43.2	60.6
315	50.5	53.1	49.3	60.4
400	49.5	55.3	44.8	59.6
500	50.3	54.3	46.8	60.4
630	53.3	56.3	50.9	63.5
800	51.9	53.9	49.2	62.0
1000	51.9	54.9	50.3	62.1
1250	53.3	56.0	50.6	63.5
1600	56.0	58.2	54.6	66.1
2000	54.0	56.1	52.3	64.1
2500	52.7	55.7	51.6	62.8
3150	51.5	57.0	48.9	61.6
4000	50.9	53.0	49.7	61.0
5000	45.7	47.9	44.5	55.7
6300	47.1	49.6	45.1	57.2
8000	45.4	49.9	44.9	55.6
10000	49.1	50.9	47.4	59.1
12500	52.9	57.9	49.9	63.0
16000	54.5	60.6	50.4	64.6
20000	46.8	53.0	44.3	57.0

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	74.1	77.8	71.1	84.2
16	70.0	77.5	58.6	80.1
20	68.6	74.2	62.4	78.7
25	75.1	78.3	72.7	85.2
31.5	63.6	69.4	57.9	73.8
40	64.1	70.5	56.1	74.2
50	61.7	69.6	51.9	71.8
63	51.9	51.8	51.5	54.7
80	59.0	64.4	54.3	69.2
100	51.4	55.2	48.9	61.8
125	56.1	64.7	49.8	66.2
160	54.0	60.9	42.5	64.1
200	59.2	62.0	51.4	69.1
250	56.5	60.9	47.3	66.6
315	54.0	59.1	51.1	64.0
400	46.4	50.4	44.1	56.5
500	49.5	54.5	44.2	59.6
630	53.8	57.1	50.2	63.9
800	57.0	63.3	50.7	67.1
1000	60.1	69.3	51.5	70.2
1250	55.7	58.0	52.2	65.8
1600	60.8	65.2	58.1	70.9
2000	56.2	58.0	54.2	66.3
2500	53.3	55.1	52.1	63.4
3150	51.0	53.3	50.1	61.1
4000	50.5	55.3	47.8	60.6
5000	47.4	49.1	46.6	57.5
6300	47.5	51.3	45.1	57.7
8000	47.4	49.3	46.0	57.5
10000	47.8	50.3	47.6	57.6
12500	49.3	52.1	47.1	59.4
16000	50.3	54.7	46.6	60.4
20000	40.5	45.5	37.1	50.6

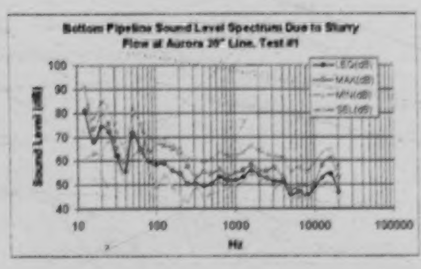
Test 3

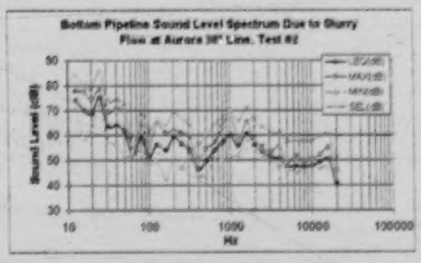
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	59.1	62.4	56.3	69.0
16	76.1	79.8	60.2	86.1
20	73.7	79.4	67.8	83.7
25	73.1	76.0	67.2	83.1
31.5	66.8	70.4	65.4	76.8
40	58.1	63.3	47.0	68.2
50	52.4	59.5	47.5	62.0
63	66.2	69.5	50.1	76.2
80	56.2	61.0	49.0	66.7
100	53.4	58.4	51.2	63.4
125	64.4	69.1	50.0	74.5
160	49.8	54.2	47.1	55.2
200	49.2	57.5	46.2	59.3
250	45.7	47.2	43.8	55.6
315	57.2	64.0	50.2	67.2
400	54.2	57.5	51.6	64.1
500	53.9	56.9	52.7	64.0
630	57.0	60.6	54.1	67.1
800	56.2	58.2	52.5	66.2
1000	55.0	56.8	54.2	65.1
1250	59.5	62.9	57.3	69.6
1600	60.9	65.2	58.4	70.9
2000	58.9	61.1	57.7	68.9
2500	56.9	59.6	55.1	66.9
3150	55.3	57.9	53.7	65.4
4000	53.5	54.9	52.4	63.6
5000	50.8	52.6	49.3	60.7
6300	53.2	55.5	51.7	63.4
8000	52.6	54.0	51.5	62.7
10000	52.4	55.2	50.0	62.5
12500	54.7	59.8	51.1	64.7
16000	53.4	55.9	50.9	63.4
20000	51.5	54.2	49.6	61.6

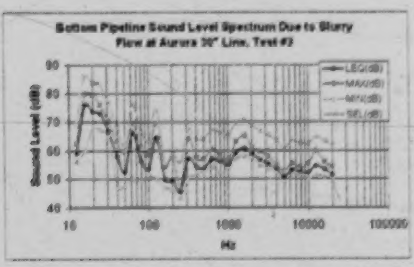
Test 4

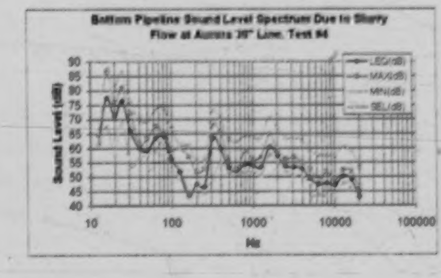
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	61.4	64.4	61.2	62.9
16	77.5	86.2	67.3	87.6
20	71.1	75.8	58.5	81.1
25	76.5	80.7	69.2	86.6
31.5	65.9	72.0	53.8	75.9
40	59.9	61.4	56.5	69.9
50	59.1	63.3	57.9	69.3
63	63.4	67.5	59.0	73.4
80	64.0	65.1	62.2	74.1
100	56.1	59.4	52.3	66.5
125	51.7	60.0	49.7	61.3
160	43.3	57.0	42.4	60.7
200	47.5	51.6	44.4	55.2
250	46.5	52.7	44.6	56.1
315	63.2	67.8	49.5	73.2
400	59.6	65.5	55.1	69.6
500	53.1	55.5	51.8	63.1
630	51.9	52.6	50.8	62.0
800	54.3	59.1	51.8	64.3
1000	53.7	56.0	51.8	63.8
1250	53.3	56.8	50.6	63.3
1600	60.4	64.8	57.7	70.5
2000	57.3	59.2	55.0	67.3
2500	53.5	56.1	52.3	63.5
3150	53.3	56.6	50.2	63.3
4000	52.7	54.9	50.2	62.6
5000	49.2	52.5	47.8	59.3
6300	47.2	48.7	44.7	57.2
8000	47.7	51.5	46.3	57.5
10000	47.0	48.3	43.3	57.1
12500	50.1	52.1	47.9	60.1
16000	48.9	51.7	46.5	58.9
20000	43.0	45.8	40.9	53.1

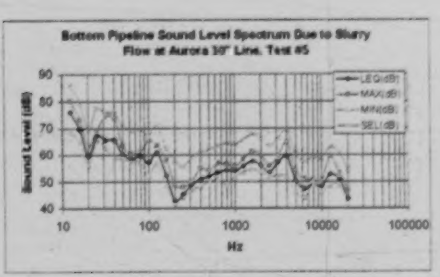
Test 5				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	75.9	80.1	69.2	86.0
16	69.5	73.0	64.7	79.6
20	59.4	63.3	56.2	69.4
25	67.2	69.1	65.6	77.3
31.5	65.6	74.4	62.4	75.7
40	65.5	73.7	58.9	75.7
50	60.4	63.5	58.4	70.5
63	58.5	60.2	57.7	68.7
80	59.6	61.1	57.3	69.5
100	57.1	65.3	52.2	67.2
125	60.8	63.5	56.9	71.0
160	52.2	58.2	48.6	62.3
200	42.9	48.9	41.8	57.9
250	45.3	47.9	44.2	55.4
315	49.0	50.0	47.0	59.1
400	50.8	54.8	48.3	60.8
500	51.9	54.0	49.9	61.9
630	53.3	56.7	50.5	63.3
800	54.2	56.4	48.9	64.2
1000	53.9	55.6	51.9	64.0
1250	55.7	58.3	53.5	65.7
1600	57.5	61.1	54.6	67.6
2000	56.1	59.9	53.5	66.1
2500	53.3	55.8	52.0	63.4
3150	57.2	59.7	52.0	66.3
4000	59.2	64.7	51.9	69.2
5000	50.4	54.2	46.2	60.4
6300	47.3	51.0	44.0	57.5
8000	48.9	50.5	49.2	59.1
10000	48.3	50.4	46.1	58.6
12500	52.7	59.4	48.7	62.8
16000	50.6	53.1	48.7	60.6
20000	43.6	46.8	41.8	53.7


Bottom Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #1
Sound Level (dB)
100
90
80
70
60
50
40
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Bottom Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #2
Sound Level (dB)
90
80
70
60
50
40
30
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Bottom Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #3
Sound Level (dB)
90
80
70
60
50
40
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Bottom Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #4
Sound Level (dB)
90
85
80
75
70
65
60
55
50
45
40
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Bottom Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #5
Sound Level (dB)
90
80
70
60
50
40
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	93.6	102.7	72.8	103.7	12.4
16	82.5	87.9	77.7	92.6	14.5
20	90.9	96.3	79.6	101.0	16.5
25	90.8	93.9	86.8	101.0	18.4
31.5	82.7	85.6	79.4	92.8	20.4
40	78.1	82.3	75.6	88.7	22.5
50	96.4	103.6	85.7	106.5	24.4
63	91.4	101.6	90.1	101.4	26.5
80	88.3	92.2	83.6	98.3	28.5
100	89.0	97.6	79.9	99.1	30.5
125	91.3	98.9	86.3	101.4	32.4
160	90.4	99.7	83.8	100.6	34.5
200	91.1	99.7	81.0	101.1	36.5
250	88.9	96.0	81.6	99.1	38.4
315	90.9	93.5	89.8	100.8	40.4
400	92.0	97.8	87.3	102.1	42.5
500	94.8	98.8	91.2	104.9	44.4
630	99.8	102.7	97.3	110.0	46.5
800	100.5	102.5	97.7	110.6	48.5
1000	102.4	105.4	100.8	112.6	50.5
1250	105.7	108.4	103.0	115.9	52.4
1600	110.5	112.8	109.2	120.6	54.5
2000	110.5	112.6	108.8	120.6	56.5
2500	111.1	114.1	110.1	121.2	58.4
3150	111.9	117.4	109.3	122.0	60.4
4000	113.4	115.6	112.3	123.5	62.5
5000	110.1	112.3	109.0	120.2	64.4
6300	113.6	116.0	111.6	123.7	66.5
8000	113.9	118.4	113.4	124.1	68.5
10000	119.5	121.4	117.9	129.5	70.5
12500	125.3	130.3	122.3	135.4	72.4
16000	129.0	135.1	125.0	139.1	74.5
20000	123.2	129.5	120.7	133.4	76.5

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	86.5	90.2	83.5	96.6	12.4
16	84.6	92.1	73.2	94.7	14.5
20	85.1	90.6	78.9	95.2	16.5
25	93.5	96.7	91.1	103.6	18.4
31.5	84.1	88.9	78.4	94.2	20.4
40	86.6	93.0	78.7	96.7	22.5
50	86.1	94.1	76.3	96.2	24.4
63	78.3	78.3	77.9	81.1	26.5
80	87.5	92.9	82.8	97.7	28.5
100	81.9	85.7	79.3	92.3	30.5
125	88.5	97.1	82.2	98.6	32.4
160	88.5	96.4	77.1	98.6	34.5
200	95.7	98.4	87.9	105.6	36.5
250	94.9	99.3	85.7	105.0	38.4
315	94.4	99.5	91.6	104.4	40.4
400	88.9	92.9	86.7	99.0	42.5
500	93.9	99.0	88.6	104.0	44.4
630	100.3	103.5	96.6	110.4	46.5
800	105.5	111.8	99.2	115.6	48.5
1000	110.5	119.8	102.0	120.6	50.5
1250	108.1	110.4	104.6	118.2	52.4
1600	115.3	119.7	112.6	125.4	54.5
2000	112.7	114.5	110.7	122.8	56.5
2500	111.7	113.5	110.5	121.8	58.4
3150	111.4	113.7	110.5	121.5	60.4
4000	113.0	117.8	110.3	123.1	62.5
5000	111.9	113.5	111.0	122.0	64.4
6300	114.0	117.8	111.6	124.1	66.5
8000	115.9	117.9	114.5	126.0	68.5
10000	118.3	120.7	118.1	128.1	70.5
12500	121.7	124.5	119.5	131.8	72.4
16000	124.9	129.3	121.1	135.0	74.5
20000	117.0	122.0	113.6	127.1	76.5

Test 3

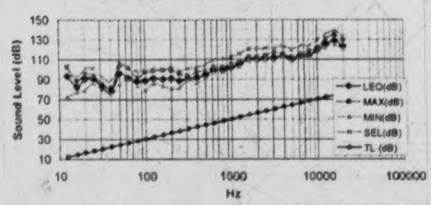
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	71.5	74.8	68.7	81.4	12.4
16	90.6	94.3	74.7	100.6	14.5
20	90.2	95.9	84.3	100.2	16.5
25	91.5	94.5	85.6	101.5	18.4
31.5	87.2	90.8	85.8	97.2	20.4
40	80.6	85.8	69.5	90.7	22.5
50	76.9	83.9	72.0	86.4	24.4
63	92.6	95.9	76.6	102.6	26.5
80	84.8	89.5	77.6	95.2	28.5
100	83.8	88.9	81.6	93.8	30.5
125	96.8	101.5	82.4	106.9	32.4
160	84.3	88.8	81.7	89.8	34.5
200	85.7	94.0	82.7	95.8	36.5
250	84.1	85.6	82.2	94.0	38.4
315	97.6	104.5	90.6	107.6	40.4
400	96.7	100.0	94.1	106.7	42.5
500	98.3	101.4	97.2	108.4	44.4
630	103.5	107.0	100.6	113.6	46.5
800	104.8	106.8	101.0	114.8	48.5
1000	105.4	107.2	104.6	115.5	50.5
1250	111.9	115.3	109.7	122.0	52.4
1600	115.4	119.7	112.9	125.4	54.5
2000	115.3	117.5	114.1	125.3	56.5
2500	115.3	118.0	113.5	125.3	58.4
3150	115.8	118.3	114.1	125.9	60.4
4000	116.0	117.4	114.9	126.1	62.5
5000	115.2	117.0	113.7	125.2	64.4
6300	119.7	122.0	118.2	129.8	66.5
8000	121.1	122.5	120.1	131.2	68.5
10000	122.8	125.7	120.4	132.9	70.5
12500	127.1	132.2	123.5	137.1	72.4
16000	128.0	130.5	125.4	138.0	74.5
20000	127.9	130.6	126.1	138.0	76.5

Test 4

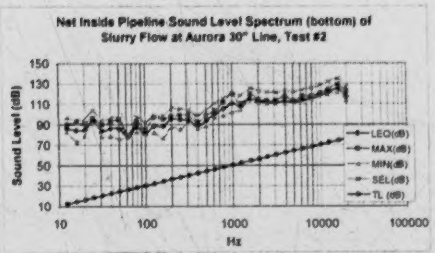
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	73.8	76.8	73.6	75.3	12.4
16	92.0	100.7	81.9	102.1	14.5
20	87.6	92.3	75.0	97.6	16.5
25	94.9	99.1	87.7	105.0	18.4
31.5	86.3	92.4	74.3	96.3	20.4
40	82.4	83.9	79.0	92.4	22.5
50	83.5	87.7	82.3	93.7	24.4
63	89.8	93.9	85.5	99.8	26.5
80	92.5	93.7	90.7	102.7	28.5
100	86.6	89.9	82.7	97.0	30.5
125	84.1	92.4	82.1	93.7	32.4
160	77.9	91.5	77.0	95.3	34.5
200	84.0	88.1	80.8	91.7	36.5
250	84.9	91.2	83.0	94.6	38.4
315	103.7	108.2	89.9	113.7	40.4
400	102.1	108.0	97.6	112.1	42.5
500	97.5	99.9	96.2	107.5	44.4
630	98.4	99.0	97.3	108.5	46.5
800	102.8	107.6	100.3	112.8	48.5
1000	104.2	106.4	102.3	114.3	50.5
1250	105.7	109.2	103.0	115.7	52.4
1600	114.9	119.3	112.2	125.0	54.5
2000	113.7	115.6	111.5	123.7	56.5
2500	112.0	114.6	110.8	122.0	58.4
3150	113.7	117.0	110.6	123.7	60.4
4000	115.2	117.4	112.7	125.1	62.5
5000	113.6	116.9	112.3	123.8	64.4
6300	113.7	115.1	111.1	123.7	66.5
8000	116.2	120.0	114.9	126.1	68.5
10000	117.5	118.8	113.8	127.6	70.5
12500	122.5	124.5	120.3	132.5	72.4
16000	123.5	126.2	121.0	133.5	74.5
20000	119.5	122.2	117.3	129.6	76.5

Test 5

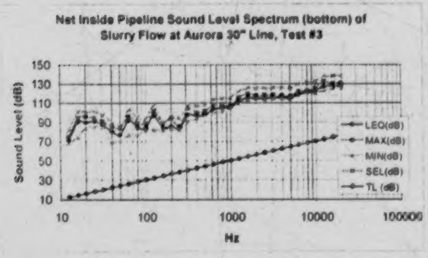
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	88.3	92.5	81.6	98.4	12.4
16	84.0	87.6	79.2	94.1	14.5
20	75.9	79.7	72.7	85.9	16.5
25	85.6	87.6	84.0	95.7	18.4
31.5	86.0	94.8	82.9	96.1	20.4
40	88.0	96.2	81.4	98.2	22.5
50	84.8	87.9	82.8	95.0	24.4
63	84.9	86.7	84.1	95.2	26.5
80	88.1	89.6	85.8	98.0	28.5
100	87.6	95.8	82.7	97.7	30.5
125	93.3	95.9	89.3	103.4	32.4
160	86.8	92.7	83.1	96.9	34.5
200	79.3	85.4	78.2	94.4	36.5
250	83.7	86.4	82.6	93.8	38.4
315	89.4	90.5	87.5	99.5	40.4
400	93.3	97.3	90.8	103.3	42.5
500	96.4	98.5	94.3	106.4	44.4
630	99.8	103.2	96.9	109.8	46.5
800	102.7	105.0	97.4	112.7	48.5
1000	104.4	106.0	102.4	114.5	50.5
1250	108.1	110.7	105.9	118.1	52.4
1600	112.1	115.6	109.2	122.2	54.5
2000	112.5	116.4	110.0	122.5	56.5
2500	111.8	114.2	110.5	121.9	58.4
3150	117.6	120.1	112.4	126.7	60.4
4000	121.7	127.2	114.4	131.7	62.5
5000	114.9	118.7	110.6	124.9	64.4
6300	113.8	117.5	110.5	123.9	66.5
8000	117.4	119.1	117.7	127.6	68.5
10000	118.8	120.9	116.6	129.0	70.5
12500	125.1	131.8	121.1	135.2	72.4
16000	125.2	127.6	123.2	135.2	74.5
20000	120.1	123.3	118.2	130.2	76.5



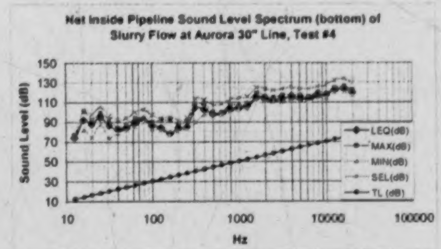
Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #1



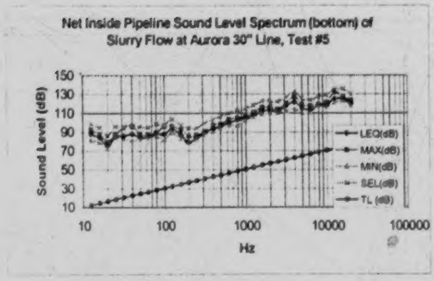
Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #2



Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #3



Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #4



Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #5

Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	93.6	102.7	72.8	103.7
16	82.5	87.9	77.7	92.6
20	90.9	96.3	79.6	101.0
25	90.8	93.9	86.8	101.0
31.5	82.7	85.6	79.4	92.8
40	78.1	82.3	75.6	88.7
50	96.4	103.6	85.7	106.5
63	91.4	101.6	90.1	101.4
80	88.3	92.2	83.6	98.3
100	89.0	97.6	79.9	99.1
125	91.3	98.9	86.3	101.4
160	90.4	99.7	83.8	100.6
200	91.1	99.7	81.0	101.1
250	88.9	96.0	81.6	99.1
315	90.9	93.5	89.8	100.8
400	92.0	97.8	87.3	102.1
500	94.8	98.8	91.2	104.9
630	99.8	102.7	97.3	110.0
800	100.5	102.5	97.7	110.6
1000	102.4	105.4	100.8	112.6
1250	105.7	108.4	103.0	115.9
1600	110.5	112.8	109.2	120.6
2000	110.5	112.6	108.8	120.6
2500	111.1	114.1	110.1	121.2
3150	111.9	117.4	109.3	122.0
4000	113.4	115.6	112.3	123.6
5000	110.1	112.3	109.0	120.2
6300	113.6	116.0	111.6	123.7
8000	113.9	118.4	113.4	124.1
10000	119.5	121.4	117.9	129.5
12500	125.3	130.3	122.3	135.4
16000	129.0	135.1	125.0	139.1
20000	123.2	129.5	120.7	133.4

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	86.5	90.2	83.5	96.6
16	84.6	92.1	73.2	94.7
20	85.1	90.6	78.9	95.2
25	93.5	96.7	91.1	103.6
31.5	84.1	89.9	78.4	94.2
40	86.6	93.0	78.7	96.7
50	86.1	94.1	76.3	96.2
63	78.3	78.3	77.9	81.1
80	87.5	92.9	82.8	97.7
100	81.9	85.7	79.3	92.3
125	88.5	97.1	82.2	98.6
160	88.5	95.4	77.1	98.6
200	95.7	98.4	87.9	105.6
250	94.9	99.3	85.7	105.0
315	94.4	99.5	91.6	104.4
400	88.9	92.9	86.7	99.0
500	93.9	99.0	88.6	104.0
630	100.3	103.5	96.6	110.4
800	105.5	111.8	99.2	115.6
1000	110.5	119.8	102.0	120.6
1250	108.1	110.4	104.6	118.2
1600	115.3	119.7	112.6	125.4
2000	112.7	114.5	110.7	122.8
2500	111.7	113.5	110.5	121.8
3150	111.4	113.7	110.5	121.5
4000	113.0	117.8	110.3	123.1
5000	111.9	113.5	111.0	122.0
6300	114.0	117.8	111.6	124.1
8000	115.9	117.9	114.5	126.0
10000	118.3	120.7	118.1	128.1
12500	121.7	124.5	119.5	131.8
16000	124.9	129.3	121.1	135.0
20000	117.0	122.0	113.6	127.1

Test 3

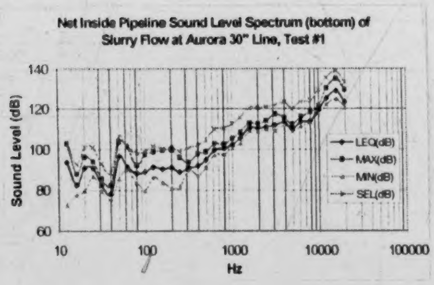
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	71.5	74.8	68.7	81.4
16	90.6	94.3	74.7	100.6
20	90.2	95.9	84.3	100.2
25	91.5	94.5	85.6	101.5
31.5	87.2	90.8	85.8	97.2
40	80.6	85.8	69.5	90.7
50	76.9	83.9	72.0	86.4
63	92.6	95.9	76.6	102.6
80	84.8	89.5	77.6	95.2
100	83.8	88.9	81.6	93.8
125	96.8	101.5	82.4	106.9
160	84.3	88.8	81.7	89.8
200	85.7	94.0	82.7	95.8
250	84.1	85.6	82.2	94.0
315	97.6	104.5	90.6	107.6
400	96.7	100.0	94.1	106.7
500	98.3	101.4	97.2	108.4
630	103.5	107.0	100.6	113.6
800	104.8	106.8	101.0	114.8
1000	105.4	107.2	104.6	115.5
1250	111.9	115.3	109.7	122.0
1600	115.4	119.7	112.9	125.4
2000	115.3	117.5	114.1	125.3
2500	115.3	118.0	113.5	125.3
3150	115.8	118.3	114.1	125.9
4000	116.0	117.4	114.9	126.1
5000	115.2	117.0	113.7	125.2
6300	119.7	122.0	118.2	129.8
8000	121.1	122.5	120.1	131.2
10000	122.8	125.7	120.4	132.9
12500	127.1	132.2	123.5	137.1
16000	128.0	130.5	125.4	138.0
20000	127.9	130.6	126.1	138.0

Test 4

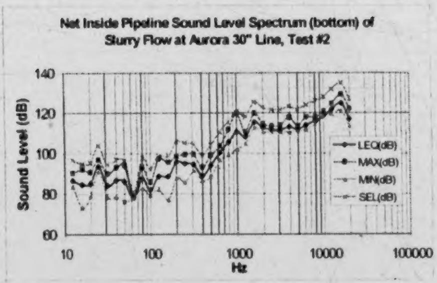
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	73.8	76.8	73.6	75.3
16	92.0	100.7	81.9	102.1
20	87.6	92.3	75.0	97.6
25	94.9	99.1	87.7	105.0
31.5	86.3	92.4	74.3	96.3
40	82.4	83.9	79.0	92.4
50	83.5	87.7	82.3	93.7
63	89.8	93.9	85.5	99.8
80	92.5	93.7	90.7	102.7
100	86.6	89.9	82.7	97.0
125	84.1	92.4	82.1	93.7
160	77.9	91.5	77.0	95.3
200	84.0	88.1	80.8	91.7
250	84.9	91.2	83.0	94.6
315	103.7	108.2	89.9	113.7
400	102.1	108.0	97.6	112.1
500	97.5	99.9	96.2	107.5
630	98.4	99.0	97.3	108.5
800	102.8	107.6	100.3	112.8
1000	104.2	106.4	102.3	114.3
1250	105.7	109.2	103.0	115.7
1600	114.9	119.3	112.2	125.0
2000	113.7	115.6	111.5	123.7
2500	112.0	114.6	110.8	122.0
3150	113.7	117.0	110.6	123.7
4000	115.2	117.4	112.7	125.1
5000	113.6	116.9	112.3	123.8
6300	113.7	115.1	111.1	123.7
8000	116.2	120.0	114.9	126.1
10000	117.5	118.8	113.8	127.6
12500	122.5	124.5	120.3	132.5
16000	123.5	126.2	121.0	133.5
20000	119.5	122.2	117.3	129.6

Test 5

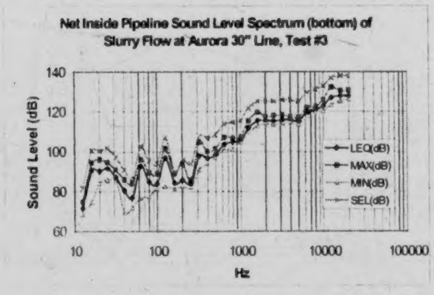
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	88.3	92.5	81.6	98.4
16	84.0	87.6	79.2	94.1
20	75.9	79.7	72.7	85.9
25	85.6	87.6	84.0	95.7
31.5	86.0	94.8	82.9	96.1
40	88.0	96.2	81.4	98.2
50	84.8	87.9	82.8	95.0
63	84.9	86.7	84.1	95.2
80	88.1	89.6	85.8	98.0
100	87.6	95.8	82.7	97.7
125	93.3	95.9	89.3	103.4
160	86.8	92.7	83.1	96.9
200	79.3	85.4	78.2	94.4
250	83.7	86.4	82.6	93.8
315	89.4	90.5	87.5	99.5
400	93.3	97.3	90.8	103.3
500	96.4	98.5	94.3	106.4
630	99.8	103.2	96.9	109.8
800	102.7	105.0	97.4	112.7
1000	104.4	106.0	102.4	114.5
1250	108.1	110.7	105.9	118.1
1600	112.1	115.6	109.2	122.2
2000	112.5	116.4	110.0	122.5
2500	111.8	114.2	110.5	121.9
3150	117.6	120.1	112.4	126.7
4000	121.7	127.2	114.4	131.7
5000	114.9	118.7	110.6	124.9
6300	113.8	117.5	110.5	123.9
8000	117.4	119.1	117.7	127.6
10000	118.8	120.9	116.6	129.0
12500	125.1	131.8	121.1	135.2
16000	125.2	127.6	123.2	135.2
20000	120.1	123.3	118.2	130.2



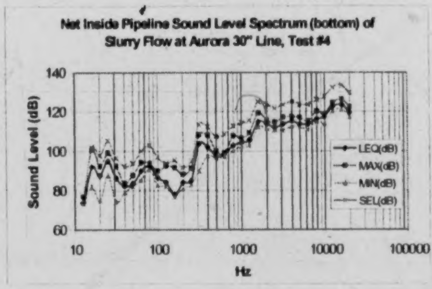
Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #1



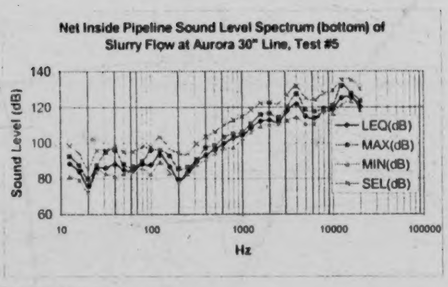
Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #2



Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #3



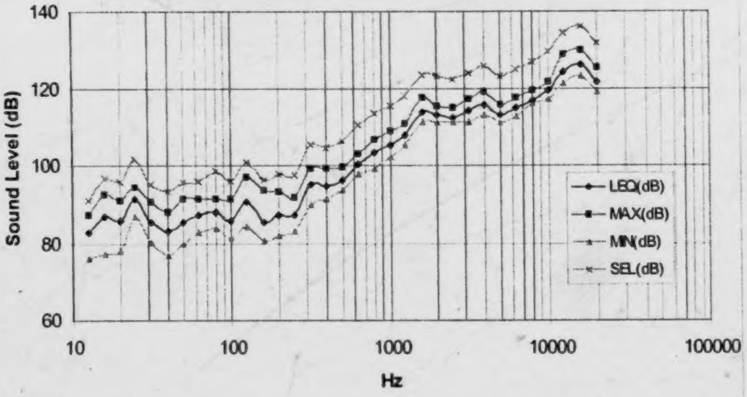
Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #4



Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line, Test #5

Average Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow
Aurora Mine

Average FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	82.7	87.4	76.0	91.1
16	86.7	92.5	77.3	96.8
20	85.9	91.0	78.1	96.0
25	91.3	94.3	87.0	101.4
31.5	85.3	90.7	80.2	95.3
40	83.1	88.2	76.8	93.3
50	85.5	91.4	79.8	95.6
63	87.4	91.3	82.8	96.0
80	88.2	91.6	84.1	98.4
100	85.8	91.6	81.3	96.0
125	90.8	97.1	84.4	100.8
160	85.6	93.6	80.5	96.2
200	87.1	93.1	82.1	97.7
250	87.3	91.7	83.0	97.3
315	95.2	99.2	89.9	105.2
400	94.6	99.2	91.3	104.6
500	96.2	99.5	93.5	106.2
630	100.3	103.1	97.7	110.4
800	103.3	106.7	99.1	113.3
1000	105.4	109.0	102.4	115.5
1250	107.9	110.8	105.3	118.0
1600	113.7	117.4	111.2	123.7
2000	113.0	115.3	111.0	123.0
2500	112.4	114.9	111.0	122.4
3150	114.1	117.3	111.4	124.0
4000	115.9	119.1	112.9	125.9
5000	113.1	115.7	111.3	123.2
6300	115.0	117.7	112.6	125.0
8000	116.9	119.6	116.1	127.0
10000	119.4	121.5	117.3	129.4
12500	124.3	128.7	121.4	134.4
16000	126.1	129.8	123.2	136.1
20000	121.5	125.5	119.2	131.7
Overall	**130.6**	**134.2**	**128.0**	**140.7**



Average Net Inside Pipeline Sound Level Spectrum (bottom) of Slurry Flow at Aurora 30" Line

7.5.3: Pipeline Side

Side Sound Level Spectrum of 30" Slurry Pipeline
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	76.8	80.9	68.2	86.8
16	81.3	85.8	76.1	91.4
20	73.9	81.7	61.8	84
25	75.8	78.7	72.3	85.9
31.5	78.5	85.1	68.6	88.6
40	74.4	79.1	70.8	84.5
50	66.5	71.6	62.2	76.6
63	62.3	65.2	59.9	72.4
80	65.9	73.4	59.6	76
100	62.4	65.4	59.8	72.5
125	64.2	71.2	59.6	74.3
160	59.6	64.7	55.4	69.6
200	54.4	57.2	53	65.5
250	51	53.8	48.7	60
315	53.6	62.5	45.3	64
400	48.8	51.3	46.8	58.8
500	50.3	52.8	48.7	60.3
630	53.2	55.4	48.7	63.3
800	55	58.1	52.4	65
1,000	56.8	65.2	52.4	66.9
1,250	54.1	56.2	52.4	64.1
1,600	52.2	54.7	50.2	62.2
2,000	53.2	56.9	50.2	63.3
2,500	50.8	52.8	49.1	60.9
3,150	50.1	53.2	48.7	60.2
4,000	48.1	49.4	46.8	58.2
5,000	47.4	48.3	46.1	57.4
6,300	46.3	48.3	45.3	56.4
8,000	51	52.1	48.9	61.6
10,000	49.6	50.9	48.7	59.7
12,500	45.1	48.4	41.8	55.1
16,000	45	46.8	42.3	55.1
20,000	37.4	41.6	35	47.4

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	68.8	72.7	60.3	78.8
16	64.6	68.9	58.4	74.7
20	71.4	74.6	67.1	81.5
25	64.5	68.9	59.2	74.6
31.5	55.8	58.1	53.6	65.8
40	59	62.2	57.3	69.1
50	60.7	63	57.5	70.7
63	61.5	63.8	58.8	71.6
80	59.8	62.3	57.4	69.6
100	57.7	60.3	56	67.7
125	61	62.2	58.5	71
160	57	58.4	56.2	67.1
200	55.1	56.8	53.7	65.2
250	49	50.6	47.9	59
315	50	52.1	48.3	60.1
400	48.2	50.6	46.8	58.2
500	50.5	52.4	48.7	60.6
630	51.8	53.9	50.6	61.9
800	52.1	53.9	49.8	62.1
1,000	53.1	56.9	51.3	63.2
1,250	54.2	58.4	52.4	64.3
1,600	54.3	57.3	52.8	64.4
2,000	53	56.9	51.7	63.1
2,500	48.6	50.2	47.6	58.6
3,150	48.2	49.8	46.8	58.2
4,000	47.9	50.2	46.8	57.9
5,000	48	50.2	46.4	58
6,300	48.5	50.6	47.2	58.6
8,000	51.3	52.4	49.4	61.3
10,000	51.3	52.4	49.8	61.4
12,500	47.3	49.1	46.1	57.4
16,000	46.8	49.8	44.9	56.9
20,000	39.6	42.3	37.8	49.7

Test 3

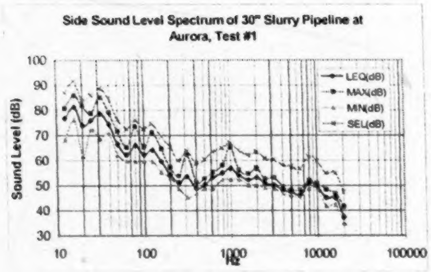
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	75.2	83.6	64.8	85.3
16	86.9	91.8	79.1	97
20	82.7	87.3	70.4	92.8
25	64.7	70.8	58.1	74.8
31.5	70.9	77.6	56.2	81
40	72.1	79.8	65.6	82.2
50	61.6	66.7	56.2	71.7
63	62	63.9	58.7	72.1
80	62.5	65.1	59.5	72.5
100	62.9	65.2	60.8	72.8
125	59.8	65.2	57.1	71
160	64.4	70.8	58.1	74.5
200	54.9	58.4	52.8	65
250	53.9	58.1	49.8	63.9
315	49.3	52.4	47.6	59.4
400	51.2	54.7	47.9	61.2
500	52.9	55.1	51.7	63
630	54.8	56.9	52.8	64.8
800	55	56.6	52.4	65
1,000	56.7	58.8	53.9	66.8
1,250	56.2	59.9	54.7	66.3
1,600	57.8	59.6	55.8	67.8
2,000	56.5	58.4	54.7	66.5
2,500	52.5	54.3	51.3	62.6
3,150	51.4	52.8	50.2	61.5
4,000	49.8	52.1	49.1	59
5,000	56.6	58.4	54.3	66.6
6,300	53.8	57.3	50.6	63.9
8,000	52.2	54.3	50.2	62.2
10,000	52.1	53.9	50.9	62.2
12,500	50	52.1	48.3	60.1
16,000	51.3	55.1	48.3	61.4
20,000	41.5	44.6	39.7	51.5

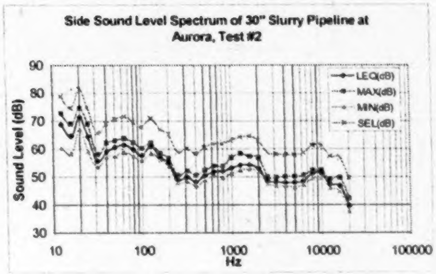
Test 4

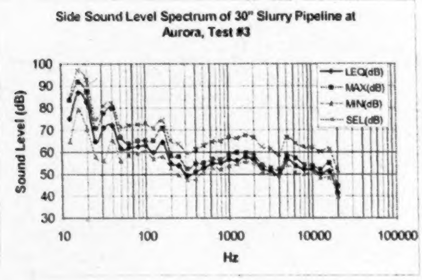
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	72.7	76.4	68.6	82.8
16	68.4	71.9	63.3	78.5
20	65	75	61.1	76.1
25	78.4	83.6	67.8	88.4
31.5	75.3	79.8	69.7	85.4
40	66.4	70.4	59.9	76.4
50	61.5	64.3	59	71.5
63	66.1	70.8	60.3	76.1
80	66.9	70.1	62.9	77
100	61.7	64.8	59.4	71.7
100	61.7	64.8	58.8	71.7
160	58.6	63.7	54.4	68.7
200	53.9	57.7	51.5	63.9
250	52.6	56.6	49.4	62.6
315	53.2	58.1	48.7	63.3
400	50.1	52.8	47.6	60.2
500	51.9	54.3	48.7	62
630	53.8	58.4	50.9	63.8
800	52.6	54.7	49.8	62.6
1,000	52.1	53.9	50.2	62.2
1,250	52.4	54.3	50.6	62.4
1,600	54.3	57.7	50.6	64.4
2,000	53.2	55.4	51.7	63.3
2,500	50.8	53.9	49.1	60.8
3,150	48.5	49.4	46.8	58.5
4,000	48.5	49.8	47.2	58.5
5,000	47.8	49.1	46.1	57.8
6,300	50.4	52.4	48.7	60.4
8,000	50.6	51.7	49.1	60.7
10,000	51.8	53.6	50.2	61.9
12,500	47.1	50.6	44.6	57.2
16,000	47.1	52.1	44.6	57.1
20,000	39.9	42.3	37.4	49.9

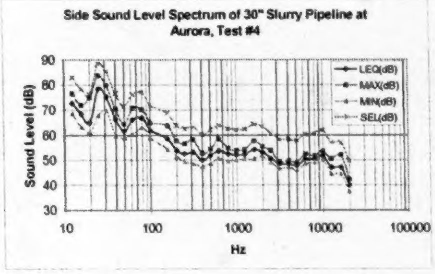
Test 5

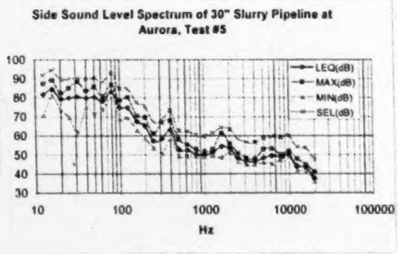
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	81.7	87.3	70.8	91.8
16	84.4	89.2	80.9	94.5
20	79.3	82.4	73.4	89.4
25	79.9	85.1	69.7	90
31.5	80.5	88.4	62.2	90.5
40	79.8	83.6	74.9	89.8
50	80.3	85.8	71.9	90.4
63	78.2	80.9	73.8	88.2
80	83.1	86.9	80.6	93.1
100	74.8	78.3	68.9	84.9
125	74.8	80.2	69.3	84.8
160	67.5	70.4	62.9	77.5
200	65.3	69.7	58.8	75.4
250	57.3	61.1	53.6	67.3
315	58.4	67.1	50.6	68.4
400	63.1	67.8	58.4	73.2
500	52.7	58.1	49.4	62.7
630	52.5	55.4	49.1	62.5
800	50.3	52.8	49.1	60.3
1,000	49.9	51.7	48.7	59.9
1,250	51.3	52.8	49.5	61.3
1,600	54.4	61.4	48.7	64.5
2,000	53.3	55.8	51.7	63.4
2,500	48.3	50.9	46.4	58.4
3,150	46.7	48.3	45	56.7
4,000	46.5	47.9	44.7	56.5
5,000	48.3	52.8	46.1	58.4
6,300	49.5	53.2	45.3	59.5
8,000	49.1	50.2	47.4	59.1
10,000	50.1	51.9	48.9	60.1
12,500	44	47.9	41.9	54.1
16,000	43.4	44.9	41.7	53.4
20,000	37.5	40.8	35.9	47.6


Side Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #1


Side Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #2


Side Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #3


Side Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #4


Side Sound Level Spectrum of 30" Slurry Pipeline at Aurora, Test #5

Side Pipeline Sound Level Spectrum Due to Slurry Flow
Aurora Mine

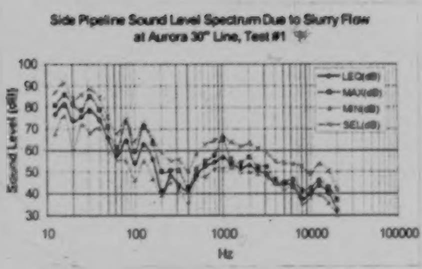
Test 1				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	76.7	80.9	67.9	86.7
16	81.3	85.8	76.1	91.4
20	73.9	81.7	61.5	84.0
25	75.7	78.6	72.1	85.8
31.5	78.4	85.1	68.2	88.5
40	74.2	78.9	70.6	84.3
50	65.7	71.2	60.5	75.8
63	58.0	61.3	55.9	67.9
80	64.5	73.0	55.1	74.5
100	54.1	59.5	46.3	64.2
125	62.7	70.8	55.1	72.8
160	55.9	63.3	47.1	65.6
200	40.9	50.3	39.5	59.0
250	48.0	50.7	45.2	55.3
315	44.0	50.7	41.8	55.7
400	41.5	43.0	36.2	50.5
500	48.5	51.4	46.8	58.4
630	52.8	55.0	47.8	62.9
800	54.5	57.8	51.8	64.5
1000	56.7	65.2	52.2	66.8
1250	53.9	56.0	52.2	63.9
1600	51.9	54.3	50.0	61.9
2000	53.1	56.8	50.1	63.2
2500	50.6	52.6	49.0	60.7
3150	48.8	52.4	47.4	58.9
4000	44.6	46.4	44.4	54.7
5000	44.4	45.3	42.2	54.2
6300	43.7	46.4	42.6	53.7
8000	37.5	41.5	35.4	52.7
10000	40.0	42.6	38.1	49.1
12500	43.7	46.1	39.6	53.6
16000	40.3	42.8	35.8	50.4
20000	32.3	37.1	30.1	41.8

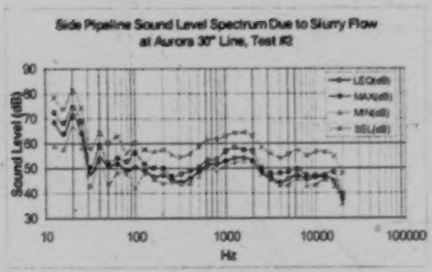
Test 2				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	68.5	72.5	59.0	78.5
16	63.9	68.2	57.7	74.0
20	71.4	74.6	67.0	81.5
25	64.2	68.7	58.6	74.3
31.5	48.1	50.4	43.0	58.1
40	54.1	58.7	52.8	64.2
50	51.1	52.4	44.0	60.1
63	51.9	54.2	48.2	62.7
80	49.2	52.7	47.8	56.1
100	50.4	56.3	42.5	60.4
125	49.2	51.6	47.9	57.5
160	46.4	50.1	45.6	56.5
200	47.4	49.9	44.1	57.5
250	45.5	46.7	44.4	55.5
315	44.4	47.6	43.8	54.5
400	46.1	48.9	44.1	56.0
500	48.6	50.5	46.8	58.7
630	51.4	53.4	50.2	61.5
800	51.7	53.5	49.2	61.7
1000	52.9	56.8	51.1	63.0
1250	54.1	58.3	52.2	64.2
1600	54.2	57.2	52.7	64.3
2000	52.9	56.8	51.6	63.0
2500	48.5	50.1	47.5	58.5
3150	46.1	47.9	45.4	56.1
4000	44.2	47.9	43.3	54.0
5000	45.7	48.5	43.4	55.7
6300	47.1	49.5	45.7	57.3
8000	45.4	47.1	42.9	55.1
10000	46.4	47.1	43.3	56.5
12500	46.5	47.2	45.4	56.6
16000	44.7	48.4	42.8	54.8
20000	37.6	39.6	35.9	47.7

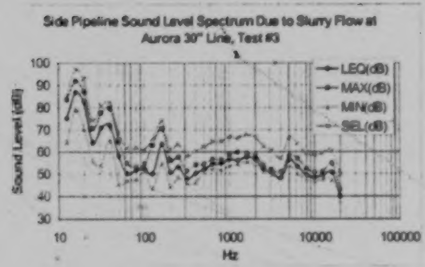
Test 3				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	75.1	83.6	64.6	85.2
16	86.9	91.8	79.1	97.0
20	82.7	87.3	70.4	92.8
25	64.1	70.6	56.0	74.2
31.5	70.7	77.5	54.1	80.8
40	71.9	79.7	65.3	82.0
50	58.4	65.0	45.6	68.5
63	50.2	55.0	46.9	61.5
80	51.9	53.3	47.7	61.9
100	52.3	54.6	51.2	61.0
125	50.2	63.1	43.6	65.9
160	63.6	70.5	54.8	73.7
200	50.9	56.3	44.5	61.0
250	53.3	57.7	48.5	63.3
315	47.9	51.5	45.9	58.0
400	50.4	54.2	46.3	60.4
500	52.1	54.5	51.0	62.2
630	54.5	56.6	52.5	64.5
800	54.8	56.4	52.1	64.8
1000	56.6	58.7	53.7	66.7
1250	56.1	59.9	54.6	66.2
1600	57.8	59.5	55.8	67.8
2000	56.4	58.3	54.6	66.4
2500	52.4	54.2	51.2	62.5
3150	50.7	52.0	49.8	60.8
4000	48.2	51.0	48.1	56.9
5000	56.4	58.2	54.0	66.4
6300	53.5	57.1	50.1	63.6
8000	49.5	52.4	47.5	59.5
10000	48.5	50.9	46.9	58.6
12500	49.6	51.2	47.9	59.7
16000	50.7	54.8	47.4	60.8
20000	39.8	43.1	37.8	49.8

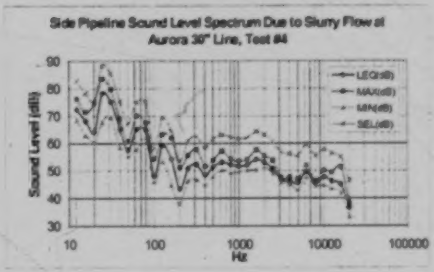
Test 4				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	72.4	76.2	68.5	82.5
16	68.2	71.5	63.1	78.3
20	64.1	74.6	60.7	75.4
25	78.3	83.5	67.7	88.3
31.5	75.2	79.7	69.5	85.3
40	65.4	68.8	58.6	75.4
50	57.5	60.7	55.3	67.5
63	65.2	70.2	57.6	75.2
80	64.9	67.4	62.0	75.1
100	48.2	54.2	45.9	58.2
125	59.2	63.2	53.5	69.1
160	54.3	62.0	44.8	64.5
200	43.3	51.2	38.0	53.3
250	50.9	55.7	46.4	60.9
315	52.4	57.8	46.8	62.5
400	48.4	51.5	44.9	58.5
500	51.4	53.8	48.0	61.5
630	53.1	57.1	50.4	63.1
800	52.2	54.3	49.3	62.2
1000	51.7	53.5	49.7	61.8
1250	52.1	54.0	50.3	62.1
1600	54.2	57.6	50.3	64.3
2000	53.1	55.3	51.6	63.2
2500	50.7	53.8	49.0	60.7
3150	46.9	47.5	45.8	56.8
4000	46.2	47.7	45.3	56.1
5000	45.6	47.0	43.1	55.6
6300	49.6	51.8	47.8	59.6
8000	45.5	46.4	44.6	55.6
10000	47.8	50.3	44.9	57.9
12500	46.2	49.3	43.5	56.3
16000	45.0	51.3	41.9	55.0
20000	36.6	38.3	33.4	46.4

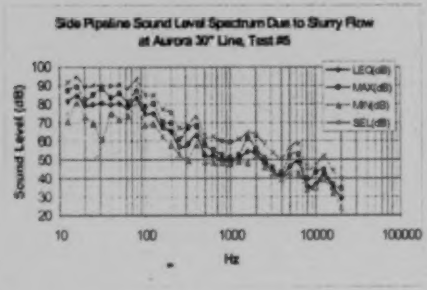
Test 5				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	81.7	87.3	70.7	91.[illegible]
16	84.4	89.2	80.9	94.5
20	79.3	82.4	73.4	89.4
25	79.9	85.1	69.6	90.0
31.5	80.5	88.4	61.1	90.5
40	79.8	83.6	74.9	89.8
50	80.3	85.8	71.8	90.4
63	78.1	80.8	73.7	88.1
80	83.1	86.9	80.6	93.1
100	74.7	78.3	68.7	84.8
125	74.7	80.2	69.1	84.7
160	67.3	70.3	62.5	77.3
200	65.1	69.6	58.0	75.2
250	57.0	60.9	53.1	67.0
315	58.3	67.1	49.9	68.3
400	63.1	67.8	58.3	73.2
500	52.5	58.0	49.0	62.5
630	52.1	55.1	48.5	62.1
800	49.8	52.4	48.6	59.8
1000	49.4	51.1	48.3	59.4
1250	51.0	52.5	49.2	61.0
1600	54.3	61.4	48.4	64.4
2000	53.2	55.7	51.6	63.3
2500	48.1	50.7	46.2	58.2
3150	43.7	45.6	42.9	53.7
4000	41.2	43.2	39.6	50.9
5000	46.3	52.0	43.1	56.5
6300	48.5	52.7	42.6	58.5
8000	35.6	39.6	33.9	45.6
10000	36.6	43.0	35.4	46.6
12500	41.8	44.4	39.5	51.9
16000	34.5	36.6	32.1	43.8
20000	29.2	34.3	24.1	39.3


Side Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #1


Side Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #2


Side Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #3


Side Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #4


Side Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #5

Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	89.1	93.3	80.3	99.1	12.4
16	95.8	100.3	90.6	105.9	14.5
20	90.4	98.2	78.0	100.5	16.5
25	94.1	97.0	90.5	104.2	18.4
31.5	98.9	105.5	88.7	109.0	20.4
40	96.7	101.4	93.1	106.8	22.5
50	90.2	95.7	84.9	100.3	24.4
63	84.4	87.8	82.3	94.3	26.5
80	93.0	101.5	83.6	103.0	28.5
100	84.6	90.0	76.8	94.7	30.5
125	95.1	103.2	87.5	105.2	32.4
160	90.4	97.8	81.7	100.1	34.5
200	77.4	86.8	76.0	95.5	36.5
250	86.4	89.1	83.7	93.7	38.4
315	84.4	91.2	82.3	96.2	40.4
400	84.0	85.5	78.7	93.0	42.5
500	92.9	95.8	91.2	102.8	44.4
630	99.2	101.4	94.3	109.3	46.5
800	103.0	106.3	100.3	113.0	48.5
1000	107.2	115.6	102.7	117.3	50.5
1250	106.3	108.4	104.6	116.3	52.4
1600	106.4	108.8	104.5	116.4	54.5
2000	109.6	113.3	106.6	119.7	56.5
2500	109.1	111.0	107.4	119.2	58.4
3150	109.3	112.9	107.9	119.3	60.4
4000	107.1	108.9	106.9	117.2	62.5
5000	108.8	109.7	106.7	118.6	64.4
6300	110.2	112.8	109.1	120.2	66.5
8000	106.1	110.1	104.0	121.2	68.5
10000	110.4	113.1	108.6	119.6	70.5
12500	116.1	118.5	112.0	126.0	72.4
16000	114.9	117.3	110.3	125.0	74.5
20000	108.8	113.6	106.6	118.3	76.5

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	80.9	84.9	71.4	90.9	12.4
16	78.4	82.7	72.2	88.5	14.5
20	87.8	91.0	83.5	97.9	16.5
25	82.6	87.1	77.0	92.7	18.4
31.5	68.5	70.8	63.5	78.5	20.4
40	76.6	81.2	75.3	86.7	22.5
50	75.5	76.9	68.5	84.6	24.4
63	78.3	80.6	74.7	89.2	26.5
80	77.8	81.2	76.3	84.7	28.5
100	80.9	86.8	73.0	90.9	30.5
125	81.6	84.0	80.3	89.9	32.4
160	81.0	84.7	80.2	91.1	34.5
200	83.8	86.4	80.5	93.9	36.5
250	84.0	85.2	82.9	94.0	38.4
315	84.8	88.0	84.2	94.9	40.4
400	88.6	91.4	86.7	98.5	42.5
500	93.0	94.9	91.2	103.1	44.4
630	97.8	99.8	96.6	107.9	46.5
800	100.2	102.0	97.7	110.2	48.5
1000	103.4	107.3	101.6	113.5	50.5
1250	106.5	110.7	104.6	116.6	52.4
1600	108.7	111.8	107.2	118.8	54.5
2000	109.4	113.3	108.1	119.5	56.5
2500	106.9	108.5	105.9	116.9	58.4
3150	106.6	108.3	105.8	116.5	60.4
4000	106.7	110.4	105.8	116.5	62.5
5000	110.2	112.9	107.8	120.1	64.4
6300	113.6	115.9	112.1	123.7	66.5
8000	114.0	115.6	111.4	123.7	68.5
10000	116.9	117.5	113.8	127.0	70.5
12500	118.9	119.6	117.8	129.0	72.4
16000	119.3	122.9	117.3	129.4	74.5
20000	114.1	116.1	112.4	124.2	76.5

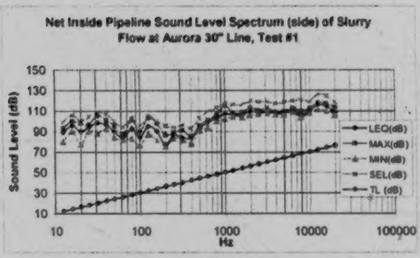
Test 3

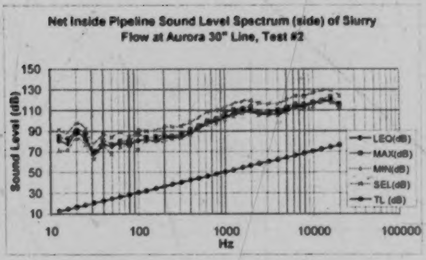
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	87.5	96.0	77.0	97.6	12.4
16	101.4	106.3	93.6	111.5	14.5
20	99.2	103.8	86.9	109.3	16.5
25	82.5	89.0	74.4	92.6	18.4
31.5	91.2	97.9	74.5	101.3	20.4
40	94.5	102.3	87.8	104.6	22.5
50	82.8	89.4	70.1	92.9	24.4
63	76.7	81.5	73.4	88.0	26.5
80	80.5	81.9	76.3	90.5	28.5
100	82.8	85.1	81.6	91.5	30.5
125	82.6	95.5	76.0	98.3	32.4
160	98.1	105.1	89.3	108.3	34.5
200	87.4	92.7	81.0	97.5	36.5
250	91.7	96.2	87.0	101.7	38.4
315	88.3	91.9	86.3	98.5	40.4
400	92.9	96.7	88.8	102.9	42.5
500	96.6	98.9	95.4	106.7	44.4
630	101.0	103.1	99.0	111.0	46.5
800	103.3	104.9	100.6	113.3	48.5
1000	107.1	109.2	104.2	117.2	50.5
1250	108.5	112.3	107.0	118.6	52.4
1600	112.3	114.1	110.3	122.3	54.5
2000	112.9	114.8	111.1	122.9	56.5
2500	110.9	112.6	109.7	121.0	58.4
3150	111.1	112.5	110.2	121.2	60.4
4000	110.7	113.5	110.6	119.4	62.5
5000	120.8	122.7	118.4	130.8	64.4
6300	119.9	123.6	116.5	130.0	66.5
8000	118.1	120.9	116.1	128.0	68.5
10000	119.0	121.3	117.4	129.1	70.5
12500	122.0	123.7	120.3	132.1	72.4
16000	125.2	129.3	122.0	135.3	74.5
20000	116.3	119.6	114.3	126.3	76.5

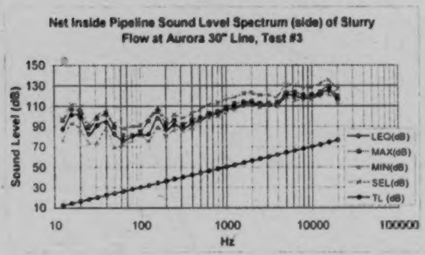
Test 4

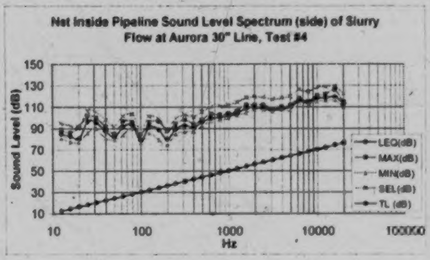
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	84.8	88.6	80.9	94.9	12.4
16	82.8	86.0	77.6	92.9	14.5
20	80.6	91.1	77.1	91.9	16.5
25	96.8	101.9	86.1	106.8	18.4
31.5	95.7	100.2	90.0	105.8	20.4
40	87.9	91.3	81.1	97.9	22.5
50	81.9	85.2	79.7	91.9	24.4
63	91.6	96.6	84.1	101.6	26.5
80	93.5	96.0	90.5	103.6	28.5
100	78.7	84.7	76.4	88.7	30.5
125	91.6	95.6	85.9	101.5	32.4
160	88.8	96.5	79.3	99.1	34.5
200	79.8	87.7	74.5	89.8	36.5
250	89.4	94.1	84.8	99.3	38.4
315	92.8	98.2	87.2	103.0	40.4
400	90.9	94.0	87.5	101.0	42.5
500	95.9	98.3	92.4	106.0	44.4
630	99.6	103.6	96.8	109.6	46.5
800	100.7	102.9	97.8	110.7	48.5
1000	102.2	104.0	100.2	112.3	50.5
1250	104.5	106.4	102.7	114.5	52.4
1600	108.7	112.1	104.9	118.8	54.5
2000	109.6	111.8	108.1	119.7	56.5
2500	109.1	112.2	107.4	119.1	58.4
3150	107.3	107.9	106.2	117.3	60.4
4000	108.7	110.2	107.8	118.6	62.5
5000	110.0	111.5	107.5	120.0	64.4
6300	116.1	118.3	114.2	126.1	66.5
8000	114.0	114.9	113.1	124.1	68.5
10000	118.3	120.7	115.3	128.4	70.5
12500	118.6	121.7	115.9	128.7	72.4
16000	119.5	125.9	116.5	129.5	74.5
20000	113.0	114.8	109.9	122.9	76.5

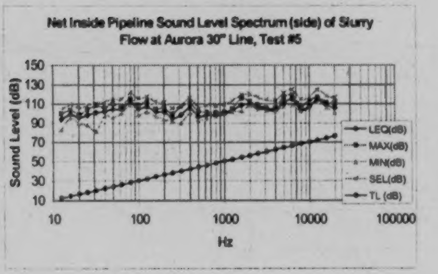
Test 5					
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	94.1	99.7	83.1	104.2	12.4
16	98.9	103.7	95.4	109.0	14.5
20	95.8	98.8	89.8	105.9	16.5
25	98.3	103.5	88.0	108.4	18.4
31.5	100.9	108.8	81.5	110.9	20.4
40	102.3	106.1	97.4	112.3	22.5
50	104.7	110.2	96.2	114.8	24.4
63	104.6	107.3	100.1	114.6	26.5
80	111.6	115.4	109.1	121.6	28.5
100	105.2	108.7	99.2	115.3	30.5
125	107.1	112.6	101.5	117.1	32.4
160	101.9	104.8	97.0	111.9	34.5
200	101.6	106.1	94.5	111.7	36.5
250	95.4	99.3	91.5	105.4	38.4
315	98.7	107.5	90.3	108.7	40.4
400	105.6	110.3	100.8	115.7	42.5
500	96.9	102.4	93.5	106.9	44.4
630	98.6	101.6	94.9	108.6	46.5
800	98.3	100.9	97.1	108.3	48.5
1000	99.9	101.6	98.7	109.9	50.5
1250	103.4	104.9	101.6	113.4	52.4
1600	108.8	115.9	102.9	118.9	54.5
2000	109.7	112.2	108.1	119.8	56.5
2500	106.5	109.2	104.6	116.6	58.4
3150	104.1	106.1	103.4	114.1	60.4
4000	103.7	106.7	102.1	113.4	62.5
5000	110.8	116.5	107.5	120.9	64.4
6300	115.0	119.2	109.1	125.0	66.5
8000	104.2	108.2	102.5	114.2	68.5
10000	107.1	113.5	105.9	117.1	70.5
12500	114.2	116.8	111.9	124.3	72.4
16000	109.1	111.2	106.6	118.3	74.5
20000	105.7	110.8	100.6	115.8	76.5


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #1


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #2


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #3


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #4


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #5

Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	89.1	93.3	80.3	99.1
16	95.8	100.3	90.6	105.9
20	90.4	98.2	78.0	100.5
25	94.1	97.0	90.5	104.2
31.5	98.9	105.5	88.7	109.0
40	96.7	101.4	93.1	106.8
50	90.2	95.7	84.9	100.3
63	84.4	87.8	82.3	94.3
80	93.0	101.5	83.6	103.0
100	84.6	90.0	76.8	94.7
125	95.1	103.2	87.5	105.2
160	90.4	97.8	81.7	100.1
200	77.4	86.8	76.0	95.5
250	86.4	89.1	83.7	93.7
315	84.4	91.2	82.3	96.2
400	84.0	85.5	78.7	93.0
500	92.9	95.8	91.2	102.8
630	99.2	101.4	94.3	109.3
800	103.0	106.3	100.3	113.0
1000	107.2	115.6	102.7	117.3
1250	106.3	108.4	104.6	116.3
1600	106.4	108.8	104.5	116.4
2000	109.6	113.3	106.6	119.7
2500	109.1	111.0	107.4	119.2
3150	109.3	112.9	107.9	119.3
4000	107.1	108.9	106.9	117.2
5000	108.8	109.7	106.7	118.6
6300	110.2	112.8	109.1	120.2
8000	106.1	110.1	104.0	121.2
10000	110.4	113.1	108.6	119.6
12500	116.1	118.5	112.0	126.0
16000	114.9	117.3	110.3	125.0
20000	108.8	113.6	106.6	118.3

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	80.9	84.9	71.4	90.9
16	78.4	82.7	72.2	88.5
20	87.8	91.0	83.5	97.9
25	82.6	87.1	77.0	92.7
31.5	68.5	70.8	63.5	78.5
40	76.6	81.2	75.3	86.7
50	75.5	76.9	68.5	84.6
63	78.3	80.6	74.7	89.2
80	77.8	81.2	76.3	84.7
100	80.9	86.8	73.0	90.9
125	81.6	84.0	80.3	89.9
160	81.0	84.7	80.2	91.1
200	83.8	86.4	80.5	93.9
250	84.0	85.2	82.9	94.0
315	84.8	88.0	84.2	94.9
400	88.6	91.4	86.7	98.5
500	93.0	94.9	91.2	103.1
630	97.8	99.8	96.6	107.9
800	100.2	102.0	97.7	110.2
1000	103.4	107.3	101.6	113.5
1250	106.5	110.7	104.6	116.6
1600	108.7	111.8	107.2	118.8
2000	109.4	113.3	108.1	119.5
2500	106.9	108.5	105.9	116.9
3150	106.6	108.3	105.8	116.5
4000	106.7	110.4	105.8	116.5
5000	110.2	112.9	107.8	120.1
6300	113.6	115.9	112.1	123.7
8000	114.0	115.6	111.4	123.7
10000	116.9	117.5	113.8	127.0
12500	118.9	119.6	117.8	129.0
16000	119.3	122.9	117.3	129.4
20000	114.1	116.1	112.4	124.2

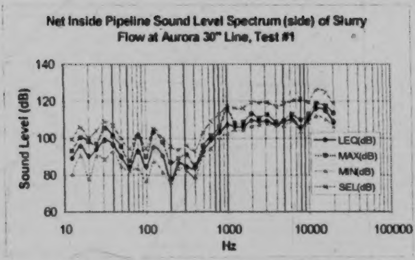
Test 3

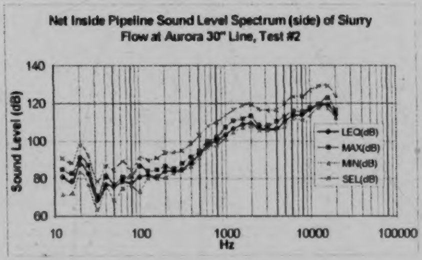
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	87.5	96.0	77.0	97.6
16	101.4	106.3	93.6	111.5
20	99.2	103.8	86.9	109.3
25	82.5	89.0	74.4	92.6
31.5	91.2	97.9	74.5	101.3
40	94.5	102.3	87.8	104.6
50	82.8	89.4	70.1	92.9
63	76.7	81.5	73.4	88.0
80	80.5	81.9	76.3	90.5
100	82.8	85.1	81.6	91.5
125	82.6	95.5	76.0	98.3
160	98.1	105.1	89.3	108.3
200	87.4	92.7	81.0	97.5
250	91.7	96.2	87.0	101.7
315	88.3	91.9	86.3	98.5
400	92.9	96.7	88.8	102.9
500	96.6	98.9	95.4	106.7
630	101.0	103.1	99.0	111.0
800	103.3	104.9	100.6	113.3
1000	107.1	109.2	104.2	117.2
1250	108.5	112.3	107.0	118.6
1600	112.3	114.1	110.3	122.3
2000	112.9	114.8	111.1	122.9
2500	110.9	112.6	109.7	121.0
3150	111.1	112.5	110.2	121.2
4000	110.7	113.5	110.6	119.4
5000	120.8	122.7	118.4	130.8
6300	119.9	123.6	116.5	130.0
8000	118.1	120.9	116.1	128.0
10000	119.0	121.3	117.4	129.1
12500	122.0	123.7	120.3	132.1
16000	125.2	129.3	122.0	135.3
20000	116.3	119.6	114.3	126.3

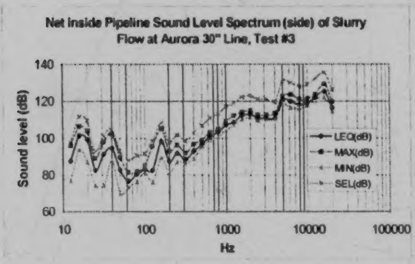
Test 4

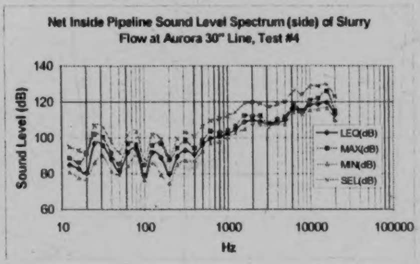
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	84.8	88.6	80.9	94.9
16	82.8	86.0	77.6	92.9
20	80.6	91.1	77.1	91.9
25	96.8	101.9	86.1	106.8
31.5	95.7	100.2	90.0	105.8
40	87.9	91.3	81.1	97.9
50	81.9	85.2	79.7	91.9
63	91.6	96.6	84.1	101.6
80	93.5	96.0	90.5	103.6
100	78.7	84.7	76.4	88.7
125	91.6	95.6	85.9	101.5
160	88.8	96.5	79.3	99.1
200	79.8	87.7	74.5	89.8
250	89.4	94.1	84.8	99.3
315	92.8	98.2	87.2	103.0
400	90.9	94.0	87.5	101.0
500	95.9	98.3	92.4	106.0
630	99.6	103.6	96.8	109.6
800	100.7	102.9	97.8	110.7
1000	102.2	104.0	100.2	112.3
1250	104.5	106.4	102.7	114.5
1600	108.7	112.1	104.9	118.8
2000	109.6	111.8	108.1	119.7
2500	109.1	112.2	107.4	119.1
3150	107.3	107.9	106.2	117.3
4000	108.7	110.2	107.8	118.6
5000	110.0	111.5	107.5	120.0
6300	116.1	118.3	114.2	126.1
8000	114.0	114.9	113.1	124.1
10000	118.3	120.7	115.3	128.4
12500	118.6	121.7	115.9	128.7
16000	119.5	125.9	116.5	129.5
20000	113.0	114.8	109.9	122.9

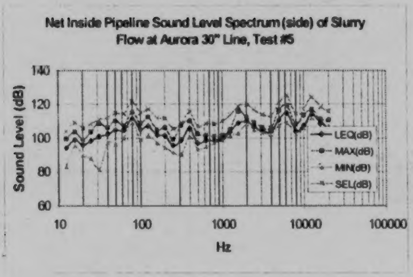
Test 5				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	94.1	99.7	83.1	104.2
16	98.9	103.7	95.4	109.0
20	95.8	98.8	89.8	105.9
25	98.3	103.5	88.0	108.4
31.5	100.9	108.8	81.5	110.9
40	102.3	106.1	97.4	112.3
50	104.7	110.2	96.2	114.8
63	104.6	107.3	100.1	114.6
80	111.6	115.4	109.1	121.6
100	105.2	108.7	99.2	115.3
125	107.1	112.6	101.5	117.1
160	101.9	104.8	97.0	111.9
200	101.6	106.1	94.5	111.7
250	95.4	99.3	91.5	105.4
315	98.7	107.5	90.3	108.7
400	105.6	110.3	100.8	115.7
500	96.9	102.4	93.5	106.9
630	98.6	101.6	94.9	108.6
800	98.3	100.9	97.1	108.3
1000	99.9	101.6	98.7	109.9
1250	103.4	104.9	101.6	113.4
1600	108.8	115.9	102.9	118.9
2000	109.7	112.2	108.1	119.8
2500	106.5	109.2	104.6	116.6
3150	104.1	106.1	103.4	114.1
4000	103.7	105.7	102.1	113.4
5000	110.8	116.5	107.5	120.9
6300	115.0	119.2	109.1	125.0
8000	104.2	108.2	102.5	114.2
10000	107.1	113.5	105.9	117.1
12500	114.2	116.8	111.9	124.3
16000	109.1	111.2	106.6	118.3
20000	105.7	110.8	100.6	115.8


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #1
Sound Level (dB)
140
120
100
80
60
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #2
Sound Level (dB)
140
120
100
80
60
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

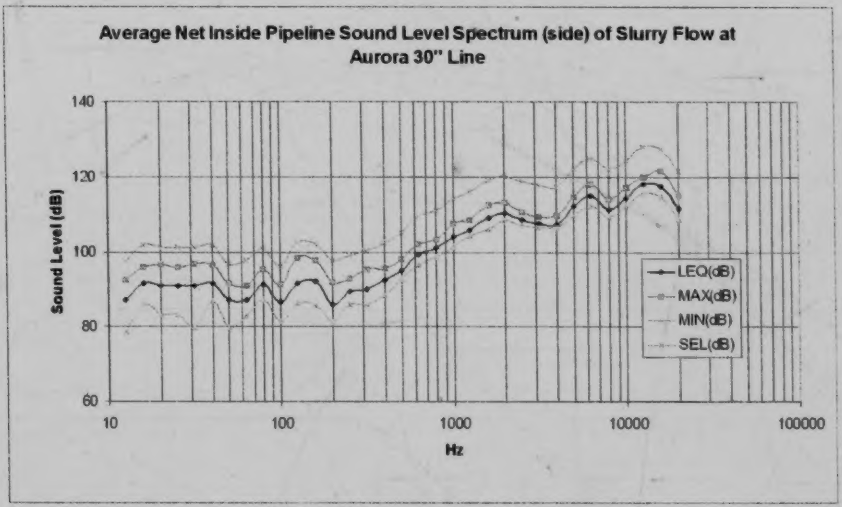

Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #3
Sound level (dB)
140
120
100
80
60
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #4
Sound Level (dB)
140
120
100
80
60
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)


Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line, Test #5
Sound Level (dB)
140
120
100
80
60
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

Average Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow
Aurora Mine

Average				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	87.3	92.5	78.6	97.4
16	91.5	95.8	85.9	101.6
20	90.7	96.6	83.1	101.1
25	90.8	95.7	83.2	100.9
31.5	91.0	96.6	79.6	101.1
40	91.6	96.5	86.9	101.6
50	87.0	91.5	79.9	96.9
63	87.1	90.8	82.9	97.5
80	91.3	95.2	87.2	100.7
100	86.4	91.1	81.4	96.2
125	91.6	98.2	86.3	102.4
160	92.0	97.8	85.5	102.1
200	86.0	91.9	81.3	97.7
250	89.4	92.8	86.0	98.8
315	89.8	95.4	86.1	100.2
400	92.4	95.6	88.5	102.2
500	95.1	98.1	92.8	105.1
630	99.2	101.9	96.3	109.3
800	101.1	103.4	98.7	111.1
1000	103.9	107.5	101.5	114.0
1250	105.9	108.5	104.1	115.9
1600	109.0	112.5	106.0	119.1
2000	110.2	113.1	108.4	120.3
2500	108.5	110.7	107.0	118.5
3150	107.7	109.5	106.7	117.7
4000	107.4	109.7	106.6	117.0
5000	112.1	114.7	109.6	122.1
6300	114.9	118.0	112.2	125.0
8000	111.3	113.9	109.4	122.2
10000	114.3	117.2	112.2	124.2
12500	117.9	120.1	115.6	128.0
16000	117.6	121.3	114.5	127.5
20000	111.6	115.0	108.8	121.5
Overall	124.3	127.2	121.9	134.3


Average Net Inside Pipeline Sound Level Spectrum (side) of Slurry Flow at Aurora 30" Line
140
120
100
80
60
Sound Level (dB)
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

7.5.4: Pipeline Top

Top Sound Level Spectrum of 30" Slurry Pipeline
Aurora Mine

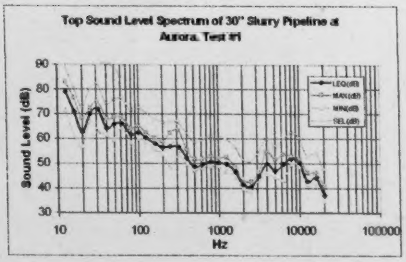
Test 1				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	79	82.8	71.6	89.1
16	70.7	76.4	61.4	80.8
20	62.7	68.2	56.6	72.8
25	70	72.3	67.4	80.1
31.5	71.9	74.9	62.9	82
40	64.2	68.2	61.4	74.3
50	65.8	68.6	59.5	75.8
63	66	68.6	64.4	76
80	61.5	64.2	58.2	71.5
100	62.5	65.1	60.1	72.5
125	60.3	62.4	58.4	70.4
160	58	60.3	55.6	68.1
200	56.4	58.8	53.6	66.5
250	56.8	62.2	48.3	66.9
315	56.5	63.5	53	66.5
400	52.2	55.4	49.8	62.3
500	48.5	51.7	47.2	58.6
630	49.6	51.7	48.3	59.7
800	50.7	52.8	48.7	60.8
1,000	50.2	52.1	48.7	60.3
1,250	49.7	52.4	46.8	59.8
1,600	46.6	48.3	44.6	56.7
2,000	41.4	43.4	39.7	51.5
2,500	40.7	42.7	38.9	50.7
3,150	44.7	46.2	43.3	54.8
4,000	49.7	54.7	45.7	59.8
5,000	47	51.7	44.6	57.1
6,300	49.6	53.6	43.4	59.7
8,000	51.9	52.9	49.7	62.4
10,000	50.2	51.7	48.7	60.3
12,500	42.7	46.2	41.2	52.8
16,000	44.2	46.1	42	54.3
20,000	37.1	40.8	34.8	47.2

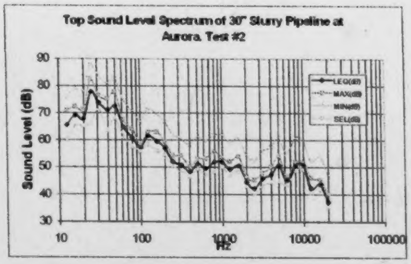
Test 2				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	65.5	70.8	60.3	75.6
16	69.1	72.3	65.2	79.1
20	67.8	71.2	65.2	77.8
25	77.7	82.4	66.3	87.8
31.5	73.7	76.4	71.6	83.8
40	70.9	75.3	63.7	81
50	72.5	77.6	68.2	82.6
63	64.8	67.4	61.4	74.8
80	60.8	64.1	57.7	70.8
100	57.2	58.5	56.1	67
125	61.5	62.8	58.7	71.5
160	59.5	62.9	56.2	69.6
200	56.9	59.2	54.7	66.9
250	52.1	54.3	50.6	62.2
315	50.8	54.3	49.1	60.5
400	48.3	50.2	46.8	58.4
500	51.3	53.2	49.4	61.3
630	49.6	53.2	47.6	59.7
800	51.9	55.8	48.7	61.9
1,000	51.8	53.6	50.2	61.9
1,250	49.2	52.1	47.2	59.2
1,600	50.6	53.9	48.7	60.6
2,000	44.6	48.4	43.1	54.7
2,500	42.2	45.3	40.4	52.3
3,150	45.8	47.9	43.2	55.9
4,000	47.4	50.2	44.6	57.5
5,000	50.8	54.3	44.9	60.9
6,300	45.2	46.8	43.8	55.3
8,000	50.8	51.8	49	60.9
10,000	50.8	52	49.3	60.1
12,500	42.2	46.2	40.8	52.2
16,000	43.8	45.3	41.9	54.1
20,000	37.1	40.1	35.6	47.2

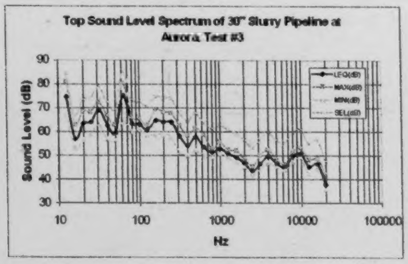
Test 3				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	74.6	80.9	67.4	84.6
16	56.9	62.9	52.8	66.9
20	63.4	68.6	56.6	73.5
25	63.9	68.2	58.8	73.9
31.5	69.1	72.3	62.9	79.1
40	62.6	66.7	56.9	72.6
50	59.3	62.8	56.4	69.4
63	75.1	80.2	64.1	85.1
80	63.4	65.9	60	73.4
100	63.1	65.3	60.7	72.9
125	60.8	62.9	58.8	70.9
160	64.7	69.3	58.8	74.7
200	64	68.2	59.2	74
250	64	67.8	57.7	74
315	58.1	62.6	51.3	68.1
400	54.2	58.4	50.2	64.3
500	57.7	61.4	52.1	67.8
630	53.5	58.8	50.2	63.6
800	51.3	52.8	49.4	61.3
1,000	52.8	55.8	50.6	62.9
1,250	50.9	52.4	49.4	60.9
1,600	49.2	52.1	47.2	59.2
2,000	46.6	48.7	45.3	56.6
2,500	43.4	45.3	41.9	53.4
3,150	46.4	50.2	44.2	56.4
4,000	49.7	52.4	46.8	59.8
5,000	46.5	48.3	45.3	56.5
6,300	45.3	46.4	44	55.3
8,000	49.8	51.7	47.2	59.8
10,000	50.8	53.2	49.4	60.9
12,500	45.2	48.3	42.3	55.2
16,000	46.5	48.7	44.6	56.5
20,000	37.7	41.9	35.7	47.7

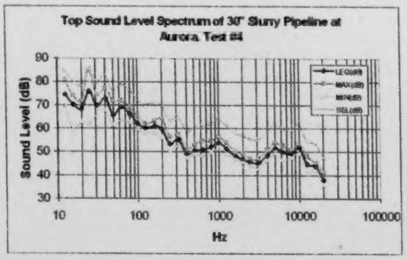
Test 4				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	74.6	80.9	69.7	84.6
16	70.2	74.2	59.2	80.2
20	68.4	71.9	62.9	78.4
25	75.9	84.8	62.2	86
31.5	69.9	74.6	65.6	80
40	73	77.2	68.2	83.1
50	65.8	71.9	61.4	75.8
63	69.2	71.9	63.7	79.2
80	66.3	69.3	62.6	76.3
100	62.2	65.4	59.8	72.2
125	60.2	62.2	58.4	70.3
160	61	63.3	58.4	71.1
200	59.7	64.4	56.2	69.7
250	53.4	56.6	50.6	63.4
315	55.3	57.7	52.8	65.3
400	49	51.3	47.9	59
500	50.7	53.2	49.1	60.7
630	50.9	54.8	48.7	60.9
800	52.2	54.7	49.8	62.2
1,000	53.9	56.6	51.7	63.9
1,250	51.4	53.9	49.4	61.4
1,600	48.3	50.6	47.2	58.3
2,000	46.9	49.1	45.7	56.9
2,500	45.7	47.2	44.6	55.7
3,150	45.4	47.1	43	55.4
4,000	48.7	50.9	46.4	58.7
5,000	51.7	53.9	49.8	61.7
6,300	50	52.8	46.8	60
8,000	49.4	50.9	47.6	59.4
10,000	51.9	53.6	49.4	61.9
12,500	44.8	48.3	41.6	54.9
16,000	43.8	45.3	42	53.5
20,000	37.9	41.1	35.9	47.5

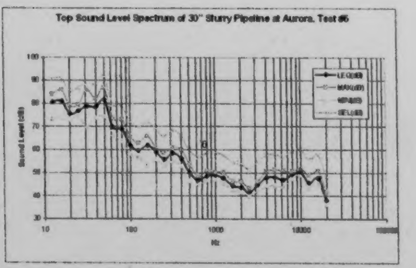
Test 5				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	80.6	83.9	73.4	90.6
16	81.1	85.8	73.8	91.1
20	75.5	79.1	73.1	85.6
25	76.8	79.4	74.2	86.9
31.5	78.9	85.8	70.1	89
40	78.4	82.1	73.8	88.5
50	81.7	86.9	74.2	91.7
63	69.7	73.4	66.7	79.7
80	68.9	73.1	63.7	79
100	61.8	65.9	58.1	71.9
125	59.6	62.9	56.6	69.6
160	61.9	65.9	53.6	72
200	59.1	61.1	55.8	69.1
250	55.8	58.8	53.6	65.8
315	58.5	60.7	55.1	68.5
400	56.1	59.9	52.8	66.2
500	50	53.9	46.4	60
630	46.8	48.3	45.3	56.8
800	48.7	50.9	46.8	58.7
1,000	48.8	50.2	47.2	58.8
1,250	47.7	50.2	45.7	57.7
1,600	44.4	46.4	42.7	54.5
2,000	43.8	46.4	41.6	53.9
2,500	41.5	43.4	40.1	51.5
3,150	44.8	46.1	42.2	54.9
4,000	47.9	50.6	44.2	57.9
5,000	48.1	51.3	44.6	58.1
6,300	47	50.9	44.2	57.1
8,000	49.2	50.6	47.5	59.3
10,000	50.2	51.8	49	60.3
12,500	45.7	49.1	43.8	55.8
16,000	47.8	50.6	45.7	57.8
20,000	38.1	41.6	36.3	48.2


Top Sound Level Spectrum of 30" Slurry Pipeline at Aurora. Test #1


Top Sound Level Spectrum of 30" Slurry Pipeline at Aurora. Test #2


Top Sound Level Spectrum of 30" Slurry Pipeline at Aurora. Test #3


Top Sound Level Spectrum of 30" Slurry Pipeline at Aurora. Test #4


Top Sound Level Spectrum of 30" Slurry Pipeline at Aurora. Test #5

Top Pipeline Sound Level Spectrum Due to Slurry Flow
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	79.0	82.8	71.5	89.1
16	70.7	76.4	61.2	80.8
20	62.3	68.0	55.6	72.4
25	69.4	71.7	66.7	79.5
31.5	71.6	74.7	61.3	81.7
40	60.9	65.2	59.0	71.0
50	64.9	67.8	55.5	74.9
63	64.6	67.2	63.4	74.6
80	55.0	58.3	48.6	64.2
100	54.8	58.2	50.5	64.2
125	54.7	58.2	50.1	64.8
160	50.3	53.8	48.3	59.8
200	52.4	55.3	45.9	62.3
250	56.2	61.9	44.3	66.3
315	53.8	57.6	52.6	63.7
400	50.2	53.7	47.1	60.2
500	45.3	49.8	44.2	55.4
630	48.6	50.7	47.4	58.7
800	49.2	51.5	47.2	59.3
1000	49.8	51.7	48.2	59.9
1250	49.2	51.9	46.1	59.3
1600	45.3	45.9	43.7	55.3
2000	39.7	41.8	38.0	49.8
2500	38.8	39.7	37.5	48.7
3150	35.8	38.9	34.4	45.2
4000	47.6	54.0	42.2	57.7
5000	43.5	50.6	36.9	53.5
6300	48.6	53.1	38.1	58.7
8000	45.4	46.7	42.8	56.8
10000	43.7	46.4	38.1	53.4
12500	39.8	41.1	38.5	49.8
16000	37.3	40.8	34.3	47.4
20000	31.2	34.3	29.5	41.0

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	64.8	70.4	59.0	74.9
16	68.9	72.0	65.1	78.8
20	67.7	71.1	65.1	77.7
25	77.7	82.4	66.2	87.8
31.5	73.6	76.3	71.5	83.7
40	70.7	75.2	63.0	80.8
50	72.2	77.5	67.8	82.3
63	62.5	65.3	58.4	72.5
80	55.2	60.2	50.0	65.2
100	46.6	47.9	44.3	53.5
125	53.8	55.9	49.8	63.2
160	56.4	61.3	45.6	66.5
200	53.4	56.5	49.4	63.3
250	50.7	53.0	49.1	60.9
315	46.8	52.2	45.8	55.8
400	46.2	48.3	44.1	56.3
500	49.8	51.7	47.8	59.7
630	48.8	52.6	46.7	58.9
800	51.5	55.5	47.9	61.5
1000	51.6	53.4	49.9	61.7
1250	48.7	51.8	46.7	58.7
1600	50.3	53.7	48.4	60.3
2000	43.7	45.5	42.2	53.8
2500	41.5	44.9	39.6	51.6
3150	41.1	44.4	38.9	51.2
4000	42.9	47.9	34.0	53.0
5000	49.8	53.7	39.6	59.9
6300	41.5	43.3	39.3	51.7
8000	43.1	44.5	40.7	53.2
10000	44.6	45.5	40.4	49.5
12500	39.0	41.1	37.8	48.9
16000	37.6	38.8	35.4	48.5
20000	32.6	33.9	31.7	42.7

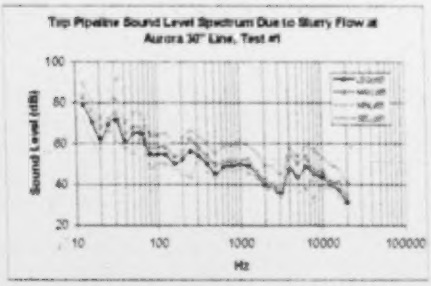
Test 3

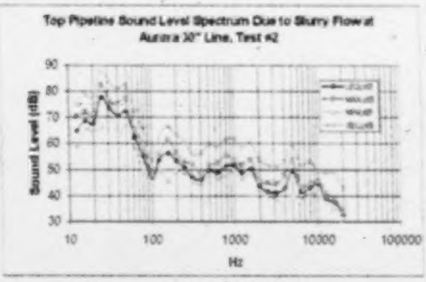
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	74.5	80.9	67.3	84.5
16	56.4	62.6	51.9	66.4
20	63.2	68.5	56.2	73.3
25	63.2	67.8	57.1	73.2
31.5	68.8	72.0	62.5	78.8
40	61.0	65.4	53.9	70.9
50	49.7	55.9	47.5	59.8
63	74.9	80.1	62.7	84.9
80	57.5	59.4	52.3	67.5
100	54.2	55.7	50.1	62.3
125	55.5	58.2	54.3	65.6
160	64.0	68.9	56.1	74.0
200	63.7	68.0	58.3	73.7
250	63.9	67.8	57.5	73.9
315	57.9	62.5	50.7	67.9
400	53.8	58.2	49.3	63.9
500	57.5	61.3	51.5	67.6
630	53.1	58.6	49.7	63.2
800	50.7	52.2	48.8	60.7
1000	52.6	55.6	50.3	62.7
1250	50.7	52.2	49.2	60.7
1600	48.8	51.7	46.8	58.8
2000	45.8	47.8	44.7	55.8
2500	42.8	44.0	41.4	52.8
3150	43.4	48.7	42.1	53.4
4000	48.0	51.4	44.9	58.1
5000	43.5	45.9	41.3	53.4
6300	42.1	42.9	40.8	52.1
8000	42.9	47.2	38.6	52.5
10000	44.6	49.3	41.1	54.7
12500	43.8	45.9	40.4	53.7
16000	44.2	47.0	42.3	54.1
20000	31.5	38.4	26.1	41.2

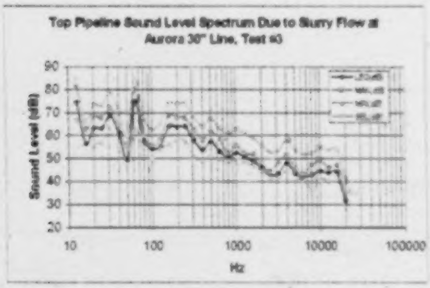
Test 4

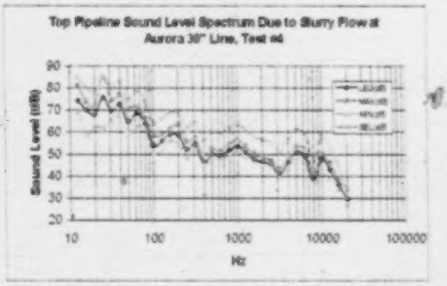
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	74.4	80.8	69.6	84.4
16	70.1	73.9	58.7	80.1
20	68.0	71.1	62.6	78.0
25	75.8	84.7	61.8	85.9
31.5	69.7	74.4	65.2	79.8
40	72.8	76.9	68.0	82.9
50	64.7	71.5	59.7	74.7
63	68.8	71.4	62.7	78.8
80	64.0	65.8	61.6	74.0
100	53.9	58.5	50.9	63.9
125	56.0	58.7	51.9	66.1
160	59.0	61.4	56.5	69.2
200	58.5	63.6	54.5	68.5
250	52.1	55.7	48.5	62.0
315	54.8	57.3	52.2	64.8
400	46.6	49.4	45.5	56.6
500	50.1	52.6	48.5	60.1
630	49.5	51.1	47.8	59.5
800	51.8	54.3	49.3	61.8
1000	53.6	56.4	51.4	63.6
1250	51.0	53.6	49.0	61.0
1600	47.7	50.1	46.6	57.7
2000	46.4	48.7	45.2	56.4
2500	45.3	46.8	44.2	55.3
3150	41.1	43.1	39.9	50.9
4000	46.5	49.3	44.0	56.4
5000	50.9	53.3	48.8	60.9
6300	49.1	52.3	45.2	59.1
8000	38.8	42.6	37.0	47.6
10000	48.0	50.3	41.1	57.9
12500	43.1	45.9	38.9	53.2
16000	36.1	38.8	34.3	43.9
20000	29.6	34.2	27.6	34.0

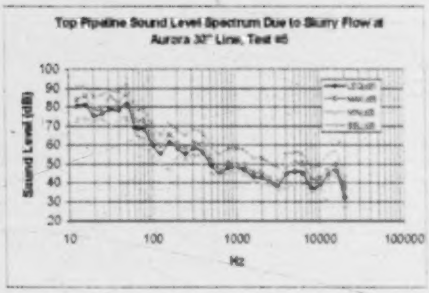
Test 5				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	80.6	83.9	73.4	90.6
16	81.1	85.8	73.8	91.1
20	75.4	79.0	73.1	85.5
25	76.7	79.3	74.2	86.8
31.5	78.9	85.8	69.9	89.0
40	78.4	82.1	73.7	88.5
50	81.7	86.9	74.1	91.7
63	69.2	73.1	66.1	79.2
80	68.4	72.8	62.6	78.5
100	60.3	65.0	55.1	70.4
125	55.4	59.4	50.4	65.4
160	61.2	65.5	47.4	71.3
200	58.2	60.1	54.1	68.1
250	55.4	58.5	53.1	65.3
315	58.4	60.6	54.9	68.4
400	55.9	59.8	52.5	66.0
500	49.5	53.6	45.6	59.5
630	45.2	46.7	43.6	55.2
800	48.0	50.3	45.9	58.0
1000	48.1	49.3	46.6	58.1
1250	47.0	49.6	44.8	57.0
1600	43.1	45.1	41.3	53.2
2000	43.0	45.8	40.6	53.1
2500	40.5	42.5	39.0	50.5
3150	38.3	39.9	36.6	48.7
4000	44.8	48.7	37.7	54.7
5000	46.0	50.2	39.3	56.0
6300	45.0	50.0	40.3	55.2
8000	37.4	42.9	35.7	48.7
10000	38.4	42.2	37.2	49.7
12500	44.3	46.8	42.4	54.4
16000	46.1	49.5	43.8	56.1
20000	32.2	37.1	28.0	42.3


Top Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #1


Top Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #2


Top Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #3


Top Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #4


Top Pipeline Sound Level Spectrum Due to Slurry Flow at Aurora 30" Line, Test #5

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	91.4	95.2	83.9	101.5	12.4
16	85.2	90.9	75.7	95.3	14.5
20	78.8	84.5	72.1	88.9	16.5
25	87.8	90.1	85.1	97.9	18.4
31.5	92.1	95.1	81.8	102.2	20.4
40	83.4	87.7	81.5	93.5	22.5
50	89.3	92.3	79.9	99.3	24.4
63	91.1	93.7	89.8	101.0	26.5
80	83.5	86.9	77.1	92.7	28.5
100	85.2	88.7	80.9	94.7	30.5
125	87.1	90.6	82.5	97.2	32.4
160	84.8	88.3	82.9	94.4	34.5
200	88.9	91.8	82.3	98.8	36.5
250	94.6	100.3	82.7	104.7	38.4
315	94.3	98.1	93.0	104.1	40.4
400	92.7	96.2	89.7	102.7	42.5
500	89.7	94.2	88.6	99.8	44.4
630	96.0	97.1	93.8	105.1	46.5
800	97.7	100.1	96.7	107.8	48.5
1000	100.2	102.2	98.7	110.3	50.5
1250	101.6	104.3	98.5	111.7	52.4
1600	99.8	100.4	98.2	109.9	54.5
2000	96.2	98.3	94.5	106.3	56.5
2500	97.2	98.1	95.9	107.2	58.4
3150	96.2	99.4	94.8	105.6	60.4
4000	110.1	116.5	104.7	120.2	62.5
5000	108.0	115.0	101.3	118.0	64.4
6300	115.0	119.6	104.5	125.1	66.5
8000	113.9	115.3	111.4	125.3	68.5
10000	114.2	116.8	108.6	123.9	70.5
12500	112.2	113.5	110.9	122.2	72.4
16000	111.9	115.3	108.8	122.0	74.5
20000	107.7	110.8	105.9	117.5	76.5

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	77.2	82.8	71.4	87.3	12.4
16	83.4	86.5	79.6	93.4	14.5
20	84.2	87.6	81.6	94.2	16.5
25	96.1	100.8	84.6	106.2	18.4
31.5	94.1	96.8	92.0	104.2	20.4
40	93.2	97.7	85.5	103.3	22.5
50	96.7	101.9	92.3	106.8	24.4
63	88.9	91.7	84.8	98.9	26.5
80	83.7	88.8	78.5	93.7	28.5
100	77.1	78.4	74.8	84.0	30.5
125	86.2	88.3	82.2	95.6	32.4
160	90.9	95.9	80.2	101.0	34.5
200	89.9	93.0	85.8	99.8	36.5
250	89.2	91.5	87.5	99.3	38.4
315	87.2	92.6	86.2	96.2	40.4
400	88.7	90.8	86.7	98.8	42.5
500	94.2	96.1	92.3	104.2	44.4
630	95.3	99.0	93.1	105.4	46.5
800	100.0	104.0	96.5	110.0	48.5
1000	102.0	103.8	100.4	112.1	50.5
1250	101.1	104.2	99.1	111.1	52.4
1600	104.9	108.3	102.9	114.9	54.5
2000	100.2	101.9	98.7	110.3	56.5
2500	99.9	103.3	98.0	110.1	58.4
3150	101.5	104.9	99.3	111.6	60.4
4000	105.4	110.4	96.5	115.5	62.5
5000	114.2	118.2	104.0	124.3	64.4
6300	107.9	109.8	105.7	118.2	66.5
8000	111.6	113.0	109.3	121.7	68.5
10000	115.1	116.0	110.9	120.0	70.5
12500	111.4	113.5	110.2	121.3	72.4
16000	112.2	113.3	109.9	123.0	74.5
20000	109.1	110.4	108.2	119.2	76.5

Test 3

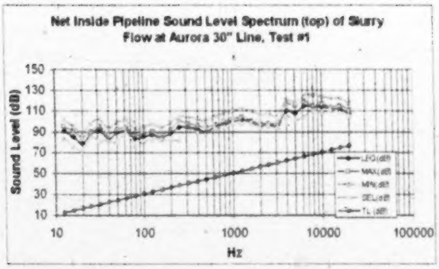
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	86.9	93.3	79.7	96.9	12.4
16	70.9	77.2	66.5	80.9	14.5
20	79.7	85.0	72.7	89.8	16.5
25	81.6	86.2	75.5	91.6	18.4
31.5	89.3	92.4	83.0	99.3	20.4
40	83.5	87.9	76.4	93.5	22.5
50	74.1	80.4	72.0	84.2	24.4
63	101.3	106.6	89.2	111.3	26.5
80	86.1	87.9	80.8	96.1	28.5
100	84.7	86.1	80.6	92.8	30.5
125	87.9	90.6	86.7	98.0	32.4
160	98.5	103.4	90.7	108.5	34.5
200	100.1	104.5	94.7	110.1	36.5
250	102.4	106.2	95.9	112.4	38.4
315	98.4	102.9	91.1	108.4	40.4
400	96.3	100.7	91.9	106.4	42.5
500	101.9	105.7	95.9	112.0	44.4
630	99.6	105.1	96.2	109.7	46.5
800	99.3	100.7	97.3	109.2	48.5
1000	103.0	106.1	100.7	113.1	50.5
1250	103.1	104.6	101.6	113.1	52.4
1600	103.4	106.3	101.4	113.4	54.5
2000	102.3	104.3	101.1	112.3	56.5
2500	101.2	102.5	99.8	111.2	58.4
3150	103.8	109.1	102.5	113.8	60.4
4000	110.6	113.9	107.4	120.7	62.5
5000	107.9	110.3	105.7	117.8	64.4
6300	108.5	109.4	107.2	118.5	66.5
8000	111.5	115.7	105.2	121.0	68.5
10000	115.1	119.8	111.6	125.2	70.5
12500	116.2	118.3	112.8	126.1	72.4
16000	118.7	121.5	116.8	128.6	74.5
20000	108.0	114.9	102.5	117.7	76.5

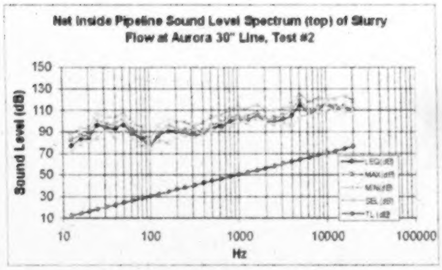
Test 4

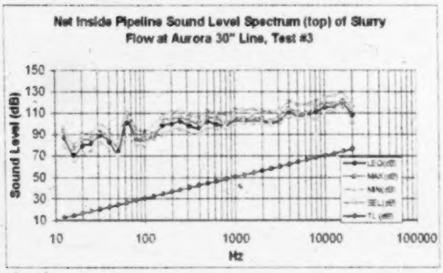
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	86.8	93.2	82.0	96.8	12.4
16	84.6	88.5	73.2	94.6	14.5
20	84.5	87.6	79.1	94.5	16.5
25	94.2	103.1	80.3	104.3	18.4
31.5	90.1	94.8	85.6	100.2	20.4
40	95.3	99.4	90.5	105.4	22.5
50	89.1	95.9	84.1	99.1	24.4
63	96.2	97.9	89.1	106.2	26.5
80	92.5	94.4	90.1	102.5	28.5
100	84.4	89.0	81.4	94.4	30.5
125	88.4	91.1	84.3	98.5	32.4
160	93.6	95.9	91.0	103.7	34.5
200	96.0	100.1	91.0	105.0	36.5
250	90.5	94.1	86.9	100.5	38.4
315	95.3	97.8	92.6	105.3	40.4
400	89.1	91.9	88.0	99.1	42.5
500	94.5	97.0	92.9	104.5	44.4
630	96.0	97.5	94.2	105.9	46.5
800	100.3	102.9	97.8	110.3	48.5
1000	104.1	106.9	101.8	114.1	50.5
1250	103.4	106.0	101.4	113.4	52.4
1600	102.2	104.6	101.2	112.2	54.5
2000	102.9	105.2	101.7	112.9	56.5
2500	103.7	105.2	102.6	113.7	58.4
3150	101.5	103.5	100.3	111.3	60.4
4000	109.0	111.8	106.5	118.9	62.5
5000	115.4	117.8	113.2	125.4	64.4
6300	115.6	118.7	111.7	125.6	66.5
8000	107.4	111.2	105.6	116.2	68.5
10000	118.5	120.7	111.6	128.4	70.5
12500	115.5	118.3	111.3	125.6	72.4
16000	110.6	113.3	108.8	118.4	74.5
20000	106.1	110.7	104.1	110.5	76.5

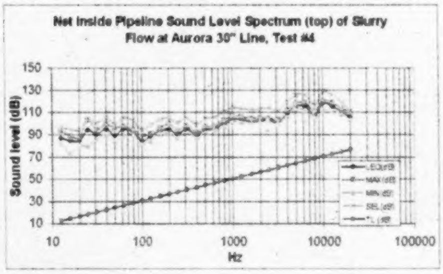
Test 5

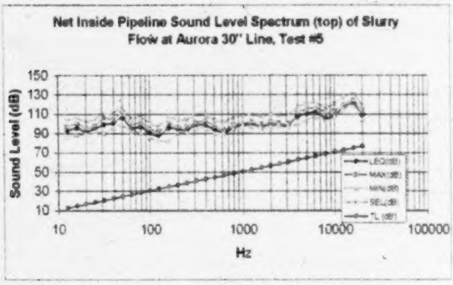
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)	TL (dB)
12.5	93.0	96.3	85.8	103.0	12.4
16	95.6	100.3	88.3	105.6	14.5
20	91.9	95.5	89.5	102.0	16.5
25	95.1	97.7	92.6	105.2	18.4
31.5	99.3	106.2	90.4	109.4	20.4
40	100.9	104.6	96.3	111.0	22.5
50	106.1	111.3	98.6	116.1	24.4
63	95.7	99.5	92.6	105.7	26.5
80	97.0	101.3	91.1	107.1	28.5
100	90.8	95.5	85.5	100.9	30.5
125	87.8	91.8	82.8	97.8	32.4
160	95.7	100.1	82.0	105.8	34.5
200	94.6	98.6	90.6	104.6	36.5
250	93.8	96.9	91.5	103.8	38.4
315	98.8	101.0	96.3	108.8	40.4
400	98.4	102.3	96.0	108.5	42.5
500	94.0	98.1	90.1	104.0	44.4
630	91.7	93.2	90.1	101.7	46.5
800	96.5	98.8	94.4	106.5	48.5
1000	98.6	99.8	97.0	108.6	50.5
1250	99.4	102.0	97.3	109.4	52.4
1600	97.7	99.7	95.8	107.8	54.5
2000	99.5	102.2	97.1	109.6	56.5
2500	98.9	100.9	97.4	108.9	58.4
3150	98.7	100.4	97.0	109.2	60.4
4000	107.3	111.2	100.2	117.2	62.5
5000	110.5	114.6	103.7	120.5	64.4
6300	111.5	116.5	106.8	121.6	66.5
8000	106.0	111.4	104.3	117.3	68.5
10000	108.9	112.6	107.7	120.2	70.5
12500	116.7	119.2	114.8	126.8	72.4
16000	120.7	124.0	118.3	130.6	74.5
20000	108.7	113.6	104.5	118.8	76.5


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #1
Sound Level (dB)
150
130
110
90
70
50
30
10
10
100
1000
10000
100000
Hz
LEQ (dB)
MAX (dB)
MIN (dB)
SEL (dB)
TL (dB)


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #2
Sound Level (dB)
150
130
110
90
70
50
30
10
10
100
1000
10000
100000
Hz
LEQ (dB)
MAX (dB)
MIN (dB)
SEL (dB)
TL (dB)


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #3
Sound Level (dB)
150
130
110
90
70
50
30
10
10
100
1000
10000
100000
Hz
LEQ (dB)
MAX (dB)
MIN (dB)
SEL (dB)
TL (dB)


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #4
Sound level (dB)
150
130
110
90
70
50
30
10
10
100
1000
10000
100000
Hz
LEQ (dB)
MAX (dB)
MIN (dB)
SEL (dB)
TL (dB)


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #5
Sound Level (dB)
150
130
110
90
70
50
30
10
10
100
1000
10000
100000
Hz
LEQ (dB)
MAX (dB)
MIN (dB)
SEL (dB)
TL (dB)

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow
Aurora Mine

Test 1

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	91.4	95.2	83.9	101.5
16	85.2	90.9	75.7	95.3
20	78.8	84.5	72.1	88.9
25	87.8	90.1	85.1	97.9
31.5	92.1	95.1	81.8	102.2
40	83.4	87.7	81.5	93.5
50	89.3	92.3	79.9	99.3
63	91.1	93.7	89.8	101.0
80	83.5	86.9	77.1	92.7
100	85.2	88.7	80.9	94.7
125	87.1	90.6	82.5	97.2
160	84.8	88.3	82.9	94.4
200	88.9	91.8	82.3	98.8
250	94.6	100.3	82.7	104.7
315	94.3	98.1	93.0	104.1
400	92.7	96.2	89.7	102.7
500	89.7	94.2	88.6	99.8
630	95.0	97.1	93.8	105.1
800	97.7	100.1	95.7	107.8
1000	100.2	102.2	98.7	110.3
1250	101.6	104.3	98.5	111.7
1600	99.8	100.4	98.2	109.9
2000	96.2	98.3	94.5	106.3
2500	97.2	98.1	95.9	107.2
3150	96.2	99.4	94.8	105.6
4000	110.1	116.5	104.7	120.2
5000	108.0	115.0	101.3	118.0
6300	115.0	119.6	104.5	125.1
8000	113.9	115.3	111.4	125.3
10000	114.2	116.8	108.6	123.9
12500	112.2	113.5	110.9	122.2
16000	111.9	115.3	108.8	122.0
20000	107.7	110.8	105.9	117.5

Test 2

FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	77.2	82.8	71.4	87.3
16	83.4	86.5	79.6	93.4
20	84.2	87.6	81.6	94.2
25	96.1	100.8	84.6	106.2
31.5	94.1	96.8	92.0	104.2
40	93.2	97.7	85.5	103.3
50	96.7	101.9	92.3	106.8
63	88.9	91.7	84.8	98.9
80	83.7	88.8	78.5	93.7
100	77.1	78.4	74.8	84.0
125	86.2	88.3	82.2	95.6
160	90.9	95.9	80.2	101.0
200	89.9	93.0	85.8	99.8
250	89.2	91.5	87.5	99.3
315	87.2	92.6	86.2	96.2
400	88.7	90.8	86.7	98.8
500	94.2	96.1	92.3	104.2
630	95.3	99.0	93.1	105.4
800	100.0	104.0	96.5	110.0
1000	102.0	103.8	100.4	112.1
1250	101.1	104.2	99.1	111.1
1600	104.9	108.3	102.9	114.9
2000	100.2	101.9	98.7	110.3
2500	99.9	103.3	98.0	110.1
3150	101.5	104.9	99.3	111.6
4000	105.4	110.4	96.5	115.5
5000	114.2	118.2	104.0	124.3
6300	107.9	109.8	105.7	118.2
8000	111.6	113.0	109.3	121.7
10000	115.1	116.0	110.9	120.0
12500	111.4	113.5	110.2	121.3
16000	112.2	113.3	109.9	123.0
20000	109.1	110.4	108.2	119.2

Test 3

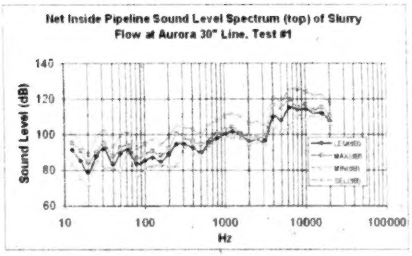
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	86.9	93.3	79.7	96.9
16	70.9	77.2	66.5	80.9
20	79.7	85.0	72.7	89.8
25	81.6	86.2	75.5	91.6
31.5	89.3	92.4	83.0	99.3
40	83.5	87.9	76.4	93.5
50	74.1	80.4	72.0	84.2
63	101.3	106.6	89.2	111.3
80	86.1	87.9	80.8	96.1
100	84.7	86.1	80.6	92.8
125	87.9	90.6	86.7	98.0
160	98.5	103.4	90.7	108.5
200	100.1	104.5	94.7	110.1
250	102.4	106.2	95.9	112.4
315	98.4	102.9	91.1	108.4
400	96.3	100.7	91.9	106.4
500	101.9	105.7	95.9	112.0
630	99.6	105.1	96.2	109.7
800	99.3	100.7	97.3	109.2
1000	103.0	106.1	100.7	113.1
1250	103.1	104.6	101.6	113.1
1600	103.4	106.3	101.4	113.4
2000	102.3	104.3	101.1	112.3
2500	101.2	102.5	99.8	111.2
3150	103.8	109.1	102.5	113.8
4000	110.6	113.9	107.4	120.7
5000	107.9	110.3	105.7	117.8
6300	108.5	109.4	107.2	118.5
8000	111.5	115.7	105.2	121.0
10000	115.1	119.8	111.6	125.2
12500	116.2	118.3	112.8	126.1
16000	118.7	121.5	116.8	128.6
20000	108.0	114.9	102.5	117.7

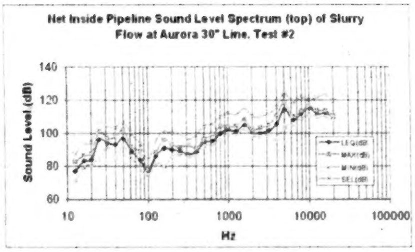
Test 4

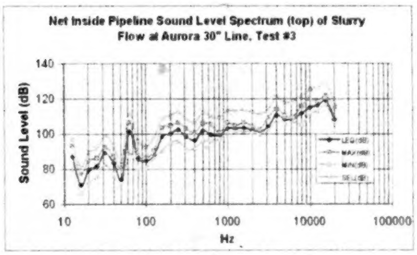
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	86.8	93.2	82.0	96.8
16	84.6	88.5	73.2	94.6
20	84.5	87.6	79.1	94.5
25	94.2	103.1	80.3	104.3
31.5	90.1	94.8	85.6	100.2
40	95.3	99.4	90.5	105.4
50	89.1	95.9	84.1	99.1
63	95.2	97.9	89.1	105.2
80	92.5	94.4	90.1	102.5
100	84.4	89.0	81.4	94.4
125	88.4	91.1	84.3	98.5
160	93.6	95.9	91.0	103.7
200	95.0	100.1	91.0	105.0
250	90.5	94.1	86.9	100.5
315	95.3	97.8	92.6	105.3
400	89.1	91.9	88.0	99.1
500	94.5	97.0	92.9	104.5
630	96.0	97.5	94.2	105.9
800	100.3	102.9	97.8	110.3
1000	104.1	106.9	101.8	114.1
1250	103.4	106.0	101.4	113.4
1600	102.2	104.6	101.2	112.2
2000	102.9	105.2	101.7	112.9
2500	103.7	105.2	102.6	113.7
3150	101.5	103.5	100.3	111.3
4000	109.0	111.8	106.5	118.9
5000	115.4	117.8	113.2	125.4
6300	115.6	118.7	111.7	125.6
8000	107.4	111.2	105.6	116.2
10000	118.5	120.7	111.6	128.4
12500	115.5	118.3	111.3	125.6
16000	110.6	113.3	108.8	118.4
20000	106.1	110.7	104.1	110.5

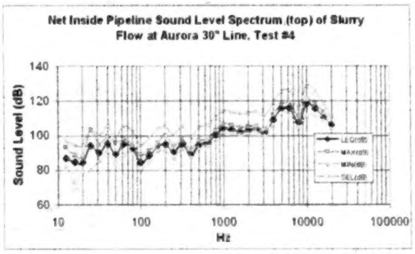
Test 5

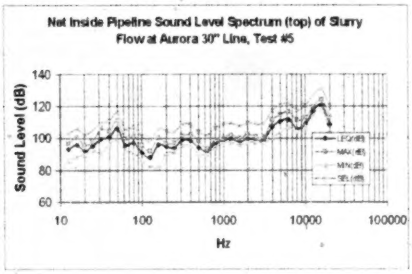
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	93.0	96.3	85.8	103.0
16	95.6	100.3	88.3	105.6
20	91.9	95.5	89.5	102.0
25	95.1	97.7	92.6	105.2
31.5	99.3	106.2	90.4	109.4
40	100.9	104.6	96.3	111.0
50	106.1	111.3	98.6	116.1
63	95.7	99.5	92.6	105.7
80	97.0	101.3	91.1	107.1
100	90.8	95.5	85.5	100.9
125	87.8	91.8	82.8	97.8
160	95.7	100.1	82.0	105.8
200	94.6	96.6	90.6	104.6
250	93.8	96.9	91.5	103.8
315	98.8	101.0	95.3	108.8
400	98.4	102.3	95.0	108.5
500	94.0	98.1	90.1	104.0
630	91.7	93.2	90.1	101.7
800	96.5	98.8	94.4	106.5
1000	98.6	99.8	97.0	108.6
1250	99.4	102.0	97.3	109.4
1600	97.7	99.7	95.8	107.8
2000	99.5	102.2	97.1	109.6
2500	98.9	100.9	97.4	108.9
3150	98.7	100.4	97.0	109.2
4000	107.3	111.2	100.2	117.2
5000	110.5	114.6	103.7	120.5
6300	111.5	116.5	106.8	121.6
8000	106.0	111.4	104.3	117.3
10000	108.9	112.6	107.7	120.2
12500	116.7	119.2	114.8	126.8
16000	120.7	124.0	118.3	130.6
20000	108.7	113.6	104.5	118.8


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #1

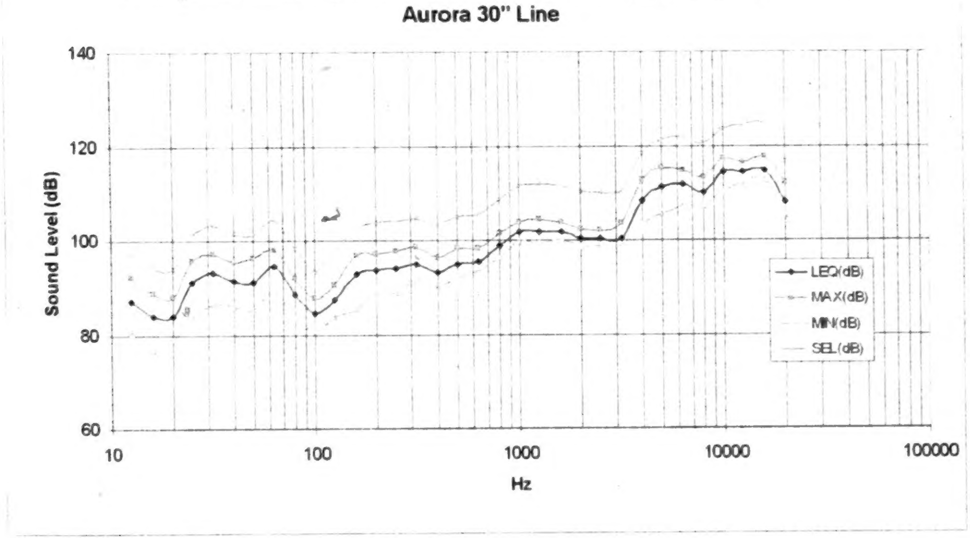

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #2


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #3


Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #4

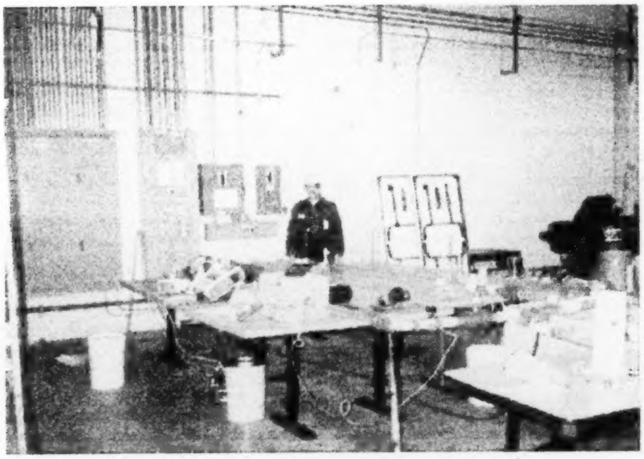

Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line, Test #5

Average				
FREQ(Hz)	LEQ(dB)	MAX(dB)	MIN(dB)	SEL(dB)
12.5	87.1	92.2	80.6	97.1
16	84.0	88.7	76.7	94.0
20	83.8	88.0	79.0	93.9
25	91.0	95.6	83.6	101.1
31.5	93.0	97.1	86.5	103.0
40	91.2	95.5	86.0	101.3
50	91.1	96.4	85.4	101.1
63	94.5	97.9	89.1	104.4
80	88.5	91.8	83.5	98.4
100	84.4	87.5	80.7	93.4
125	87.5	90.5	83.7	97.4
160	92.7	96.7	85.4	102.7
200	93.7	97.2	88.9	103.7
250	94.1	97.8	88.9	104.1
315	94.8	98.5	91.6	104.6
400	93.0	96.4	90.2	103.1
500	94.9	98.2	92.0	104.9
630	95.5	98.4	93.5	105.6
800	98.8	101.3	96.3	108.8
1000	101.6	103.7	99.7	111.7
1250	101.7	104.2	99.6	111.7
1600	101.6	103.9	99.9	111.6
2000	100.2	102.4	98.6	110.3
2500	100.2	102.0	98.8	110.2
3150	100.4	103.4	98.8	110.3
4000	108.5	112.8	103.1	118.5
5000	111.2	115.2	105.6	121.2
6300	111.7	114.8	107.2	121.8
8000	110.1	113.3	107.1	120.3
10000	114.4	117.2	110.1	123.5
12500	114.4	116.5	112.0	124.4
16000	114.8	117.5	112.5	124.5
20000	107.9	112.1	105.1	116.7
Overall	**121.7**	**124.7**	**118.4**	**131.5**

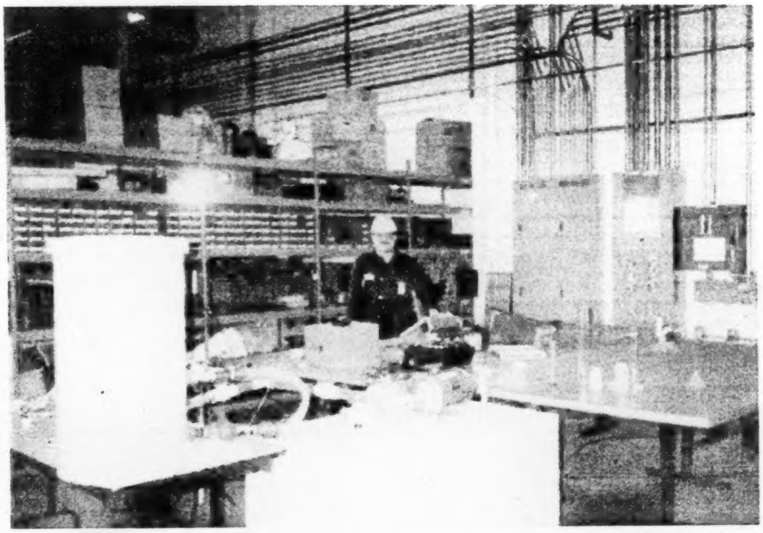

Average Net Inside Pipeline Sound Level Spectrum (top) of Slurry Flow at Aurora 30" Line
140
120
100
80
60
Sound Level (dB)
10
100
1000
10000
100000
Hz
LEQ(dB)
MAX(dB)
MIN(dB)
SEL(dB)

7.6: PICTURES

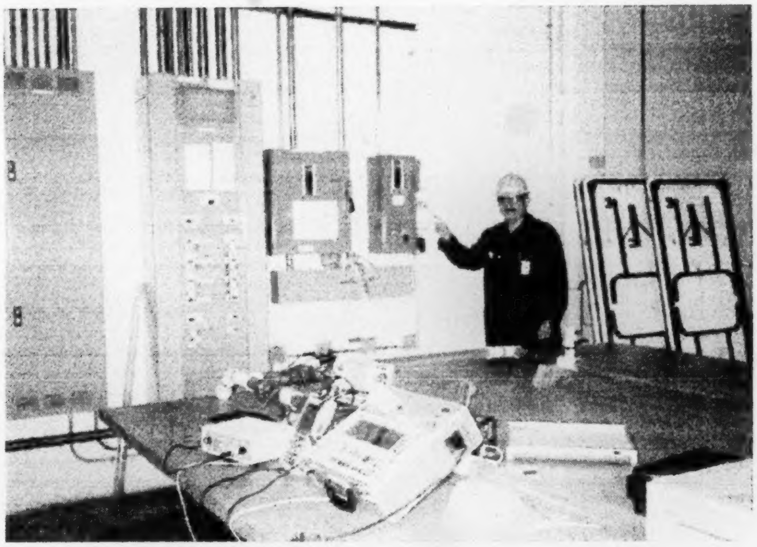
Picture 7-1: Test loop at pilot plant SRC, Resonant Frequency Test



Picture 7-2: Test loop at pilot plant SRC, Resonant Frequency Test



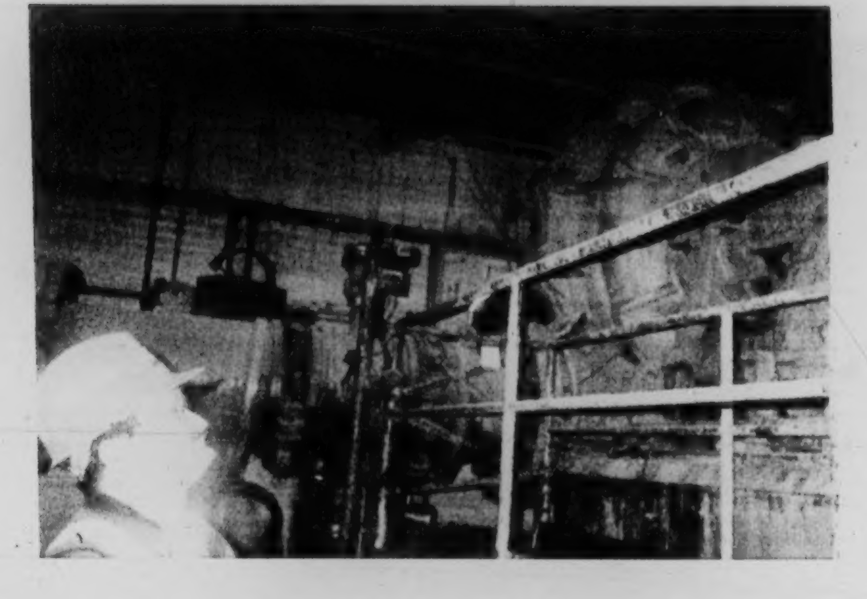
Picture 7-3: Test loop at pilot plant SRC, Resonant Frequency Test



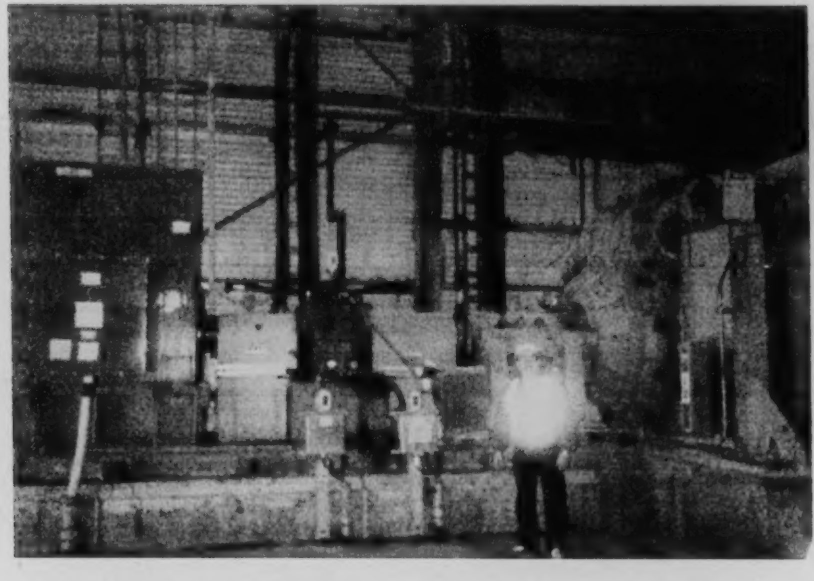
Picture 7-4: Test loop at pilot plant SRC, Resonant Frequency Test

Picture 7-5: Sound level measurement at North Mine pipeline, Noise Spectrum Test

Picture 7-6: Sound level measurement at North Mine pipeline, Noise Spectrum Test



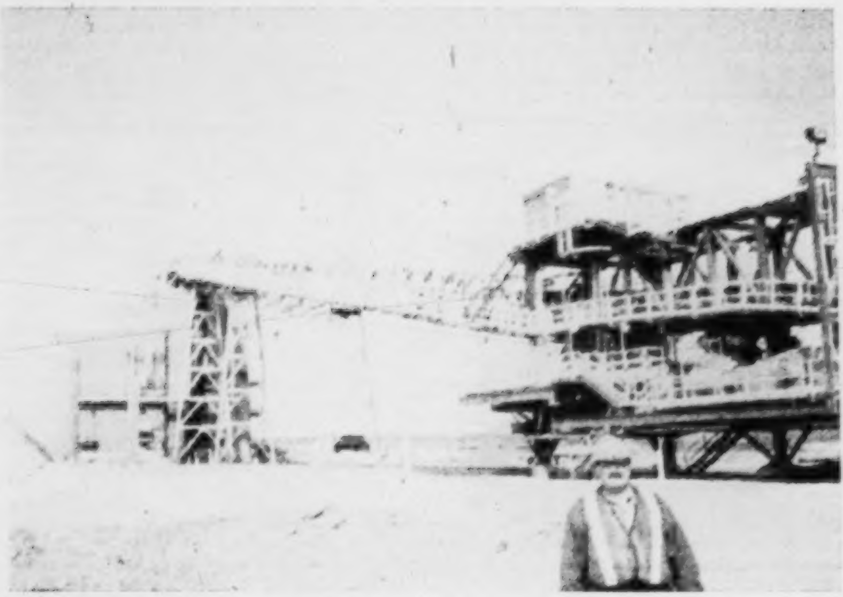
Picture 7-7: Booster pump station at North Mine



Picture 7-8: Booster pump station at North Mine

Picture 7-9: Sound level measurement at Aurora Mine pipeline, Noise Spectrum Test

Picture 7-10: Sound level measurement at Aurora Mine pipeline, Noise Spectrum Test



Picture 7-11: Conveyer Belt feed to pump station in the back, at Aurora Mine